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AVIATION BIOLOGY*

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At the present time we find the world literally and figuratively "up in the air." The subject of Aviation Biology or Aviation Medicine is being studied and applied all over the world. The air corps is instructing its men in the fundamentals of aviation biology, various universities have instituted courses in aviation medicine, the government is training medical men in the problems of aviation biology, and research laboratories are busily attempting to solve many of the problems which have become apparent in the practice of military aviation. The subject of aviation medicine is a very extensive one and one can only hope to cover the more fundamental aspects of this subject in a limited time. For purposes of discussion the subject of aviation biology can be reduced to three basic facts peculiar to the human (animal) organism: they are: 1. Man needs oxygen to sustain life, 2. Man cannot ascend to higher altitudes beyond a certain rate of speed, 3. Man cannot tolerate changes in speed and direction and beyond certain limits. Let us consider each in order.

I. The oxygen requirements of the aviator—anoxia. There are two factors which determine whether the oxygen requirements of the aviator are fulfilled, they are: a. the concentration of oxygen, and b. the partial pressure of the oxygen. The concentration of oxygen at ground level is about 21 per cent of the atmospheric pressure of 760 mm. Hg. However, opposing this is the pressure of the water vapor in the lungs which amounts to

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47 mm. Hg. Although the concentration of atmospheric oxygen is 21 per cent, it is only 14.5 per cent in the lungs since it is diluted by other pre-existing gases. Therefore, the normal effective partial pressure of oxygen at ground level is 103 mm. Hg. (or 14.5 per cent of $760-46$). The partial pressure of oxygen, therefore, will determine whether there will be an inadequate amount of oxygen for the aviator.

For example, at an altitude of 12,000 feet the atmospheric pressure is 483 mm. Hg. and the effective partial pressure of oxygen is about 63 mm. Hg. At an altitude of 18,000 feet the atmospheric pressure is 360 mm. Hg. (1/2 atmosphere) the effective partial pressure of oxygen is 48 mm. Hg. It is to be noted that the change in pressure between ground level and an altitude of 1000 feet is 27 mm. Hg., whereas the change in pressure from 39,000 to 40,000 feet the pressure change is only 6.9 mm. Hg. The altitude-pressure relationship is not a straight line and therefore there will be greater changes in the partial pressure of oxygen at the lower altitudes, but the smaller changes at the higher altitudes are of course physiologically more critical. What then are the critical altitudes as far as oxygen supply to the aviator are concerned? On the basis of our experience and the reports of other investigators the following statements can be made:

1. That the effects of anoxia commence at altitudes of 12,000 feet to 15,000 feet for most aviators. The duration at a given altitude of course is a factor.
2. There is a loss of consciousness at altitudes of 25,000 feet or over for any appreciable length of time.
3. If one uses 100 per cent oxygen the effects of anoxia do not ensue until altitudes of 27,000–33,000 feet are reached.
4. Using 100 per cent oxygen, at altitudes beyond 44,000 life, cannot be sustained for any great length of time.
5. At altitudes between 52,000 and 62,000 feet the lungs are completely filled with water vapor and carbon dioxide and no oxygen can enter (even with 100 per cent oxygen being used).

The practical implications of these facts are threefold:

1. The aviator should not fly at altitudes beyond 10,000 to 12,000 feet for any great length of time without using oxygen.
2. The aviator should not fly at altitudes beyond 30,000 feet for long periods of time even with oxygen.
3. To ascend practically to altitudes beyond 45,000 to 50,000 feet pressure cabins must be built which will maintain the ef-

fective partial pressure of oxygen. Up to the present time this has not been practically applied this in war. Pressure cabins have been used experimentally and show much promise for the future.

II. The rate of ascent-aeroembolism. When an aviator ascends to higher altitudes at a rapid rate his body tissues, body fluids and the dissolved gases are subjected to a rapid decrease in atmospheric pressure and a condition known as aeroembolism may result. Aeroembolism is a condition in which air (mostly nitrogen) bubbles form in the tissues and body fluids as a result of rapid decompression. This may be variably referred to as the bends, caisson disease, the chokes, etc., and was originally discovered in connection with caisson workers who would develop this condition when ascending rapidly to ground level. The same mechanism applies to both the caisson worker and the aviator. In each case the body is being decompressed at rates too rapidly for the body gases to adjust themselves.

Because of the great concentration of nitrogen on the air (79 per cent) this gas exerts a high partial pressure and therefore enters the pulmonary circulation in significant quantities. The nitrogen in the body is relatively inert and does not enter into the important physiological functions (as does oxygen). The nitrogen is not utilized but exists in simple solution in the body tissues. When the body is subjected to decrease in the atmospheric pressure the partial pressure of the nitrogen in the lungs is decreased and the partial pressure of the nitrogen of the tissues and fluids being relatively higher begin to come out in an attempt to establish an equilibrium. If the decrease in the atmospheric pressure is slow and gradual the body will desaturate itself of the necessary amount of nitrogen uneventfully. However, if the decrease in the atmospheric pressure is sudden and great, the nitrogen will come out of solution and form bubbles in the tissues and blood and may become emboli which obstruct the blood vessels to the heart or brain and may be fatal. There are various reactions to aeroembolism depending on the size and location of the air bubbles. There may be a severe pain and paralysis or there may just be a dull aching. The critical rates of ascent and altitudes which favor the development of aeroembolism (according to Armstrong) are: 1. rates of climb as high as 12,000 feet per minute up to altitudes of 30,000 feet rarely produce symptoms. 2. Beyond altitudes of 32,000 feet susceptible individuals may develop aeroembolism

at rates of 200 feet per minute. 3. At altitudes of 37,000 feet any reasonable rate of climb is apt to produce symptoms of aeroembolism.

Prevention of aeroembolism may be accomplished by: a) ascending very slowly, and b) by denitrogenation of the body by the use of oxygen during exercise before ascending. Should aeorembolism develop its symptoms can usually be abolished by returning to altitudes below 25,000 feet. We have only touched upon this subject since time will not permit a more thorough discussion.

III. Changes in speed and direction-acceleration. When traveling in a straight line, speeds of 500 miles per hour are harmless, although changes in the direction of flight will subject the pilot to various degrees and types of stress depending on the nature of the change. If a pilot pulls his plane up suddenly when traveling at high speed there will be a resultant centripetal force acting in the direction from head to feet. This is referred to as positive acceleration. If the pilot suddenly turns his plane downward there will be a resultant centripetal force acting in the direction from feet to head. This is known as negative acceleration. The force exerted will depend on the speed and the radius of the curved path of flight. This force is expressed as a multiple of the normal force of gravitation or G and can be determined by the equation a (accel) $= V^2/32.2r$, in which V is the velocity in feet per second, and r is the radius of the turn in feet. Thus if a pilot weighing 180 pounds at a normal gravitational force ($1G$) is traveling at a speed of 300 miles per hour and turns in a radius of 2700 feet—a force of $2.2G$ is exerted on the pilot. This force would be 396 pounds (2.2×180). All the tissues and body fluids remain correspondingly heavy as long as the high velocity flight in a curve continues. If a force of $7G$ is attained a pilot weighing 180 pounds would be subjected to a force of 1260 pounds and under these conditions the effective specific gravity of the blood would be higher than that of molten metal and the hydrostatic pressure of the blood within the vessels would be in the neighborhood of 570 mm. mercury.

There are three types of acceleration: 1. linear acceleration, 2. transverse, and 3. centrifugal. We will confine ourselves to the discussion of centrifugal acceleration, because it is the most commonly encountered in military aviation. There are two types of centrifugal acceleration: a. positive acceleration, and b. negative acceleration. Positive acceleration results from sud-

denly pulling up the airplane from a dive whereas a negative acceleration results from an outside loop or suddenly diving the airplane from a horizontal course. The symptoms and disturbances from positive acceleration are as follows: body not under control of muscles, a heavy dragging sensation, of viscera, complete loss of blood from head with blindness or blackout, painful cramping of arms and legs, respiration is embarrassed because the viscera crowd the thorax, blood pressure will go as low as 20 mm. mercury systolic with a pulse of 180. The human limits for positive acceleration is about 5*G* for three seconds. Disturbances associated with negative acceleration are as follows: head seems about to burst, eyes appear to bulge, visual field becomes red, i.e., "redding out," irreversible changes in brain and other organs may take place, there is no unconsciousness, but mental confusion lasting several days. Three to four negative *G* for a few seconds is much more serious and damaging than 7 positive *G* for ten seconds. In animals massive cerebral hemorrhage occurs in a few seconds at 6 negative *G*. At the present time there is no practical means of combating the effects of centrifugal acceleration.

BOOKS ON THE AIR AGE

Textbook materials for use in training America's youth for living in "the air age" are being prepared by a research staff of the Stanford University School of Education for the Civil Aeronautics Administration, Washington, D.C.

Under the direction of Paul R. Hanna, professor of education, a staff of 25 persons has started a six-month project which involves gathering material on aviation suitable for inclusion in textbooks and courses-of-study at elementary and junior high school levels. Stanford was assigned the project after the Civil Aeronautics Administration had been deluged with requests from textbook writers for aviation materials. The volume which will result from the present investigation will be designed to serve the needs of these writers.

Based on the necessity of developing an air-minded generation able to cope with the new problems associated with aircraft, the projected source volume will include aviation material in the arts, arithmetic, guidance and mental health, language arts, science, and social studies. Suitable curriculum content will be developed for the levels from the first grade through the ninth.

Roscoe B. Bancroft of the CAA staff in Washington has been loaned to Stanford to serve as chief aviation consultant. Mrs. Lorraine Sherer, formerly director of curriculum of the Los Angeles County public schools, is coordinator of research. Members of the Stanford faculty serving as chief consultants in the various fields include Daniel M. Mendelowitz, arts; Norman Fenton, guidance and health; L. B. Kinney, arithmetic; R. Will Burnett, science; Holland D. Roberts, language arts; and I. James Quillen, social studies.

ROCK STRATA AND OUR ENVIRONMENT

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The stratified nature of rock structures that rest beneath the surface of the earth, or project above the immediate surroundings in the form of hills or mountains, along with the positions and compositions of the various rock layers, are very important and determining factors in many natural phenomena that man uses, views with pleasure, or by which his life is modified. Therefore, the concept that deals with the relationship of these factors is of fundamental importance in the study and understanding of the phases of science that pertain to topography, mineral products, bodies of water and products of the soil.

The inter-relationship of rock stratification, position and composition is the key to the solution of many questions about the environment, gives a clearer insight into the *why* of things, and goes a long way toward establishing a more complete understanding of the geological forces that have brought geographical factors to bear on the life of man. The elements of this concept are generally found in science publications, but are seldom organized in such a way so as to direct the thinking of the student toward a clear mental picture of the concept with its useful implications.

A sound understanding of mineral deposits, soil variations, mountain barriers, stream courses and other related phenomena depend a great deal upon a well established conception that *rocks generally are or have been in layers, that such layers have undergone changes including the planes in which they rest, and that the rock layers vary in composition which leads to a difference in the rate of erosion.* A sound understanding of the principle affords the opportunity for one to have a better appreciation of the geographical environment, to understand the causes of natural phenomena and to focus his attention on the way in which tremendous geological forces of the past have determined where rivers are, how much oil has been preserved and where the tiller of the soil can prosper.

The topics listed below include situations by which the concept may be coordinated and applied. These are only a few of the many applications. In the actual teaching of the principles of the concept it would probably be much better to start with

local geographical conditions; and then, after these have been studied, diagrammed and coordinated, the more generally important examples could be studied. Some of the more important topics are:

1. Anticlines, in which layers of impervious rocks cap porous rocks, may act as reservoirs for gas and oil. (Fig. 1) Dry synclines may likewise act as collecting areas for gas and oil—these are sometimes sealed by faults.

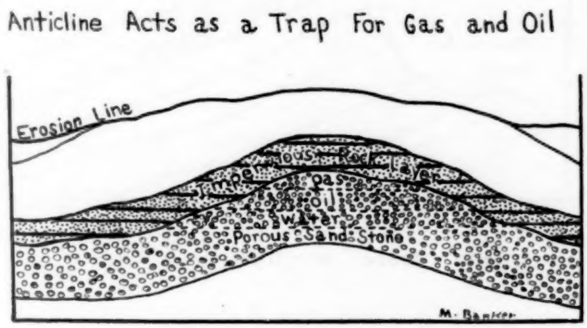

FIG. 1

2. Many coal deposits have been preserved because they rest in geological trenches which protect them, at least in part, from the forces of erosion. (Fig. 2) Nature's hoarding of portions of such a mineral is of very evident importance to man. Then too, it must be remembered that forces of upheaval have worked to convert lower grades of coal into the anthracite form.

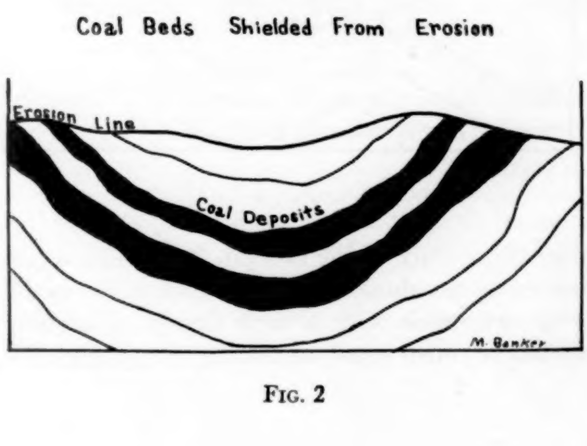

FIG. 2

3. Mountain formation often is the result of erosion on tipped rock layers where a durable type rock forms the crest. (Fig. 3) This condition often determines the angle of slope of the mountain.

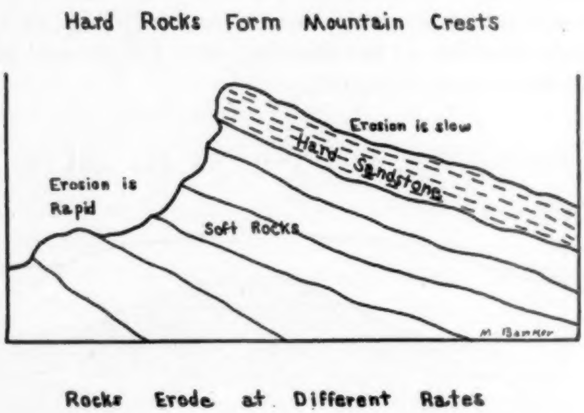

FIG. 3

4. Rock foldings with the weathering that follows determines the location of mineral out-cropping of the quarry type. (Fig. 4) This also allows an estimate to be made concerning the deposits

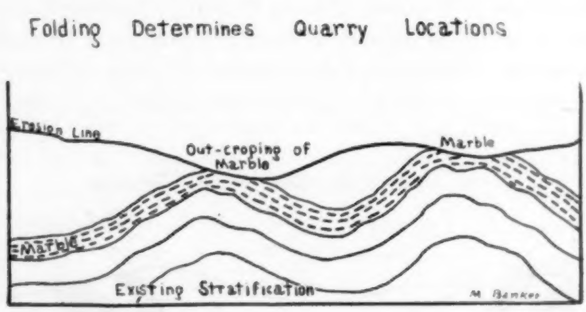

FIG. 4

deep under the surface of the ground. By getting a general idea of the out-cropping along with the angles of the beddings it is possible to determine with a high degree of accuracy where shafts should be constructed for mining certain minerals.

5. Water falls are sometimes the result of a durable rock layer resisting erosion while the softer rocks are removed.

6. Valley formation is sometimes caused by the weathering of soft rocks. (Fig. 3)

7. The variation in soil fertility and composition in many cases can be traced directly to the kind of rock that underlies the area in question.

8. The composition of the rock layers will to a very great extent determine stream courses. Streams tend to cut intrenchments in the softer rocks.

9. The general contour of the land in some cases is determined by the types of rocks underlying the region. This is, however, more of a group of minor situations.

The inter-play of the factors that go to make up this important conception must not be accepted as the one and only means explaining the situations mentioned. It must be used with the understanding other natural factors enter the pictures and spin a web of causes and effects.

WELL-TRAINED SCIENTIFIC PERSONNEL CALLED BEST NATIONAL PROTECTION

Scientists do not need to work and wait until they grow old before fame and the comforting knowledge that they are useful in the world come to them, Dr. Karl T. Compton, president of the Massachusetts Institute of Technology, assured the finalists in the Third Annual Science Talent Search.

Pointing out that a very large proportion of the greatest discoveries have been made by scientists in their twenties and early thirties. Dr. Compton admonished his young hearers: "Don't let yourselves be discouraged by observing that textbooks usually show pictures of great scientists as elderly men; this only means that their portraits were not painted until some time after their great work was done."

The present war work of scientists, Dr. Compton continued, illustrated the opportunities for young scientists and engineers. Some of the largest and most important firms now manufacturing materials for the war report that about a third of their entire engineering staffs are young people below the age of 26.

"I know one group engaged in developing a device of the very highest war priority in which 90% of the staff are below 26," the speaker declared. "There are literally no other scientists in the world who could take their places at this time, for they have themselves developed a new art."

Scientists, in Dr. Compton's opinion, are a more important part of a nation's permanent protection than warships, aircraft or artillery. These become obsolete, "but a nation possessing a great reserve of scientists and engineers can mobilize them to create still more powerful weapons of defense and offense as the need arises."

TEACHING PHYSICS EFFECTIVELY*

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First, *let's make the laboratory an attractive place.* Let's look over the old classroom critically and see whether the chalk dust of years back has enshrouded the general view with a grey pallor. Can scuff marks on the lecture desk and furniture be touched up with a mixture of furniture polish and elbow grease? Plain washing will take a lot of distracting doodle marks off chair arms and desk tops. Does apparatus shine when placed on the lecture table, or does it work in spite of dust, neglect, and need for oil? We'll gain a lot in self-respect, and in attention from our pupils (for which we compete against ever-increasing distractions) by bright apparatus with eye-appeal.

Then take a look at the walls. Will new charts and pictures liven them up? Good housekeeping pays dividends in setting the stage for accurate work from our pupils. The bulletin board needs frequent refreshing, and if asked, pupils will find much material for it from current magazines alone.

A place in the physics room for books which are available to pupils is most desirable. In addition to several secondary-school textbooks, some of the more popular-type books on physics should be available for student browsing. Among them are *Romping Through Physics*—O. W. Gail (Geo. Routledge and Sons), a delightful spirited translation from the German which is a credit to both writer and translator; *Physics Tells Why*—Overton Luhr (Jaques Cattell Press); *Mr. Tompkins in Wonderland*—G. Gramow (Macmillan); and *From Galileo to Cosmic Rays*—H. B. Lemon (U. of Chicago Press).

A "must" for every laboratory is *Demonstration Experiments in Physics*—Sutton (McGraw-Hill), a book crammed with suggestions for experiments.

College textbooks not only extend the range covered by the secondary-school books, but they include important new topics such as rotary and simple harmonic motions. Some college books should be in the high-school laboratory, especially for the use of the more able pupils. *Physics*—Hausman-Slack (D. Van Nostrand) offers an extended stalwart course. *College Physics*—

* A talk before the New York State Teachers Association, Albany, New York, December 29, 1943.

revised—N. Henry Black (Macmillan) is a very clearly written book. *College Physics*—revised—John Eldridge (John Wiley and Sons) is a bright textbook from which the following paragraph is taken (with permission):

"The phenomenon of interference was discovered by Thomas Young in 1801.

"Young was one of the most remarkable men that ever lived. He was a precocious youth; he read fluently at the age of two, read Latin at six, Greek soon after; at ten he studied Hebrew, Chaldee, Arabic, Syriac, Persian, and modern languages. He went to medical school in 1792, and a year later had investigated the crystalline lens and explained accommodation of the eye. For this he was elected to the Royal Society. In 1799 he started medical practice and got his M.D. degree nine years later. In 1801 he was professor of Natural Philosophy in the Royal Institute; there he performed his famous interference experiments and resurrected the wave theory of light. Others had thought of kinetic energy as a "living force"—Young first called it "energy." He became Superintendent of the Royal Almanac, Insurance Actuary, and Professor of Medicine. He wrote biographical articles and medical books, discovered astigmatism, and explained dispersion and capillary action. The astronomer knows of "Young's Theory of the Tides"; the psychologist knows of "Young's Theory of Color Perception"; the physics student knows of Young's Modulus; the archeologist knows of Young's work on the Rosetta stone. For when that most famous of Egyptian relics was discovered, it was Young who first deciphered it. And withal (says his biographer) he played the flute, sang, and danced."

Having a complex experiment set up and performing (extra-curriculum) is an excellent idea and a good teaching device. Every day for a week a new system of pulleys appeared on a frame in a classroom. They were suggested by reference to a large dictionary. The amount of interest was surprising.

Another experiment which works like a charm is the blow-gun—falling-body experiment. A tube is sighted at a tin can about 20 feet away which is dangling from an energized electromagnet. As a ball is blown out of the tube it breaks an electric circuit, releasing the can. The can and the projected ball hit in midair. In fact, by practice they can be made to collide in a waste-basket placed directly below the can.

A larger set-up which is appropriate to the times is one of the methods of determining the speed of a rifle bullet. In SCHOOL SCIENCE AND MATHEMATICS for December, 1943 Mr. M. J. W. Phillips gives details of two methods. One uses the traditional and fairly reliable ballistic pendulum, and the other two paper discs three feet apart which rotate on the same shaft. A third method is described in Dr. Sutton's book on page 362. It uses two strips of tinfoil and a ballistic type galvanometer in an elec-

tric circuit with a condenser. The calculations are within the range of our best pupils.

In the same issue of the same magazine Mr. Walter Thurber describes a good apparatus for magnetizing and demagnetizing steel. It seems that the same apparatus could have extended usefulness for showing Magnafluxing, an important method for testing steel for concealed cracks and flaws.

A good demonstration well performed and adequately safeguarded is a most satisfactory teaching device. But we should not go off the deep end of demonstrating and perform for the sake of entertainment only.

A demonstration to be good must be visible and clear. An electroscope made from two strips of newspaper is superior to the gold-leaf electroscope for visibility, unless the latter is projected onto a screen. See the Westinghouse booklet on *Fundamentals of Electricity* (10¢) for this and other simple ideas.

A mechanical analog of Boyle's law made from a lath (Fig. 1) helps visualize the fixed temperature and the inverse proportion, taking a hazy idea in some pupils' experience one step away from rote toward reality.

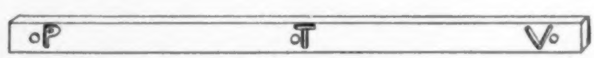

FIG. 1. Boyle's Law Stick.

A rubbed Bakelite rod behaves characteristically with puffed rice, the same material also serving as a cheap and ready substitute for pith balls. Try some puffed rice between the plates of a condenser while it is being charged. Electrostatic fields can also be shown with puffed rice or cork dust in a manner similar to showing magnetic fields with iron filings, but the cork or puffed rice has the added feature of "taking off" when it acquires enough charge. Try producing a charge on some puffed rice and then scattering the material with a like-charged rod.

Using the common electrolytic conductivity tester with wires close together it may be shown that glass is a non-conductor at room temperature but a good source of ions when fluid. This is done by melting a piece of glass tubing in a Bunsen flame and applying the conductivity test to the soft glass. Many accidental fires are hot enough to melt glass. The inference is obvious.

Discharge an electrophorus, as well as grounding it, through a

neon-filled spectrum tube, or a Geissler tube. This shows evidence of electron movement, and high voltage.

For a good Christmas experiment fill a Hoffman electrolysis apparatus with sodium sulfate solution to which some red cabbage juice has been added as an indicator. Beautiful red and green colors develop in the two arms of the apparatus, respectively.

"Curiosity is the salt which makes the student thirsty" has been well said. Here are a few "quickie" experiments which are not new, but they may be performed from very common equipment and without comment.

(a) A strip of limp paper is snapped out from beneath a pencil standing upright on its square-cut end.

(b) A calling card and coin rest on the experimenter's forefinger. The card is snapped out with the other hand.

(c) Two forks attached to a half-dollar seem suspended in midair when balanced around the corner of a table.

(d) A glass of water is suddenly whirled over one's head while being held at arm's length.

(e) A flame of burning gas is carried in the hands to light a Bunsen burner.

Questions usually follow.

While these are qualitative experiments designed to build a background of experience and to illustrate certain principles, we must not forget that physics asks eternally, "How much?", and that scientific inquiry starts when we make measurements.

II

Once a little girl was in the habit of falling out of bed. Her parents were at a loss to discover the cause of the difficulty when her sister explained, "I know why Mary falls out of bed. She goes to sleep too soon after she gets in." The same might be said of some teachers in their profession.

So, secondly, ***let's roll up our sleeves***, physically and mentally.

Physics has so many new and better things to offer that the teacher must be alert to "keep up" with them. One good way to prevent atrophy is to support a professional organization enthusiastically, and to subscribe to and read professional publications.

Some of the newer things which seem worth adopting are Alnico magnets for demonstration, a cathode-ray oscilloscope to replace some rotating mirror demonstrations, and multiple-

purpose, large-dialed electrical measuring instruments which radio-supply companies stock. Rectified A C using a copper-oxide type rectifier is a perfectly satisfactory source of D C, eliminating dry cells in all but a few experiments. In fact, as completely as possible, our laboratories should operate on 110-volt A C, and our thinking likewise should leave the Daniell cell-tangent galvanometer era. D C is important in learning the simple fundamentals of electricity and for some of its obvious applications; but the greatest use our pupils will have for electricity is for 110 or 220-volt A C, and we should act on this fact.

Spark-exposure multiple flash pictures showing the swing of a golf club, for example, are helpful in showing accelerated motion. They also point out the importance of impulse ($f \times t$) in "follow through," and suggest the reason for the long barrel on high-velocity guns. Incidentally, the return of a bowling ball serves as an interesting example of accelerated and uniform motions.

The newer detergents are worth considering. With a mixture of Drene or Dreft, for example, and water a tough soap suds-like film can be made which shows surface tension properties quickly and effectively. Interference bands are also noticeable in this experiment. A wetting agent added to water will sink a little boat made of wire screening. Agents of this sort play an important part in our technical advantage in prosecuting the war. They aid in separating valuable minerals from gangue, cleaning metals preparatory to plating, washing fabrics preparatory to dyeing, and in certain oil fields detergents which lower the surface tension are sent into formations which contain oil and water. They aid the flow of oil and retard the flow of water.

For showing the center of gravity effectively, ask a player to come forward, perch him on the lecture table, and using the football stance give a practical demonstration of the center of gravity in relationship to the base of support.

In some teachers colleges considerable time is given to the aims of education. We teachers must pull the trigger. A sure-fire demonstration is to hold a roller in place on an inclined plane by a chip. Attach a cord to the roller and extend it over a pulley to the top of the incline to a pan. When enough shot is placed in the pan, the chip may be taken away. By a similar cord perpendicular to the incline, and another pulley another pan may be counterpoised to balance the thrust of the plane.

Then the inclined plane may be taken away, leaving the roller suspended in midair. This is an excellent demonstration of the resolution of forces, a topic difficult for pupils of limited imagination and experience. Be sure to make measurements in this experiment.

In such experiments it is a fine plan to allow pupils to assist, or to perform them entirely.

Bernouilli's principle is worth much emphasis now. Here is a review of some of the simple experiments which may be performed to demonstrate this principle.

(a) A sheet of paper is placed over the channel left between two books placed about two inches apart on a table. The pupil is then invited to blow into the channel to blow the paper "off."

(b) The spool and card demonstration is an old experiment, but still instructive and cheap to make.

(c) A ping-pong ball in a jet of water or of air will perform to the open-mouthed amazement of pupils.

(d) Just blowing between two suspended 250 ml. Florence flasks with a half-inch space between will cause them to click together.

(e) With strong air pressure applied to the stem, a ping-pong ball will rotate in the neck of an inverted funnel.

(f) An atomizer which will give an impressive volume of spray can be made from two pieces of glass tubing and a piece of wire.

(g) The filter pump is a widely-used apparatus with either steam or water flowing through the nozzle.

(h) A venturi tube is readily constructed from odd pieces in a plumber's shop and the pressures at the two diameters can be measured by manometers, gages, or simply by noting the distance of flow of water from each orifice.

(i) Best of all, an air foil in a wind tunnel can be arranged to show the relative amount of force above and below it when air is flowing through the tunnel.

If you are allergic to acetamide or to naphthalene as a substance for determining the cooling curve through the freezing point, try Carbide and Chemicals Corporation's trimethylcyclohexane, a chemical with a distinct aromatic odor resembling methanol which is reported to form crystals at room temperature and to melt slightly above.

Also, let's roll up our sleeves to the mathematical challenge. Most freshmen (grade 9) have a chance at the end of their ele-

mentary algebra to do a little work with the elementary trigonometric functions. If asked, members of the class themselves will point out that the coefficient of friction on an inclined plane is the tangent of the angle of elevation, and that in the construction method of finding the index of refraction we have the ratio of the sine of the angle i to the sine of angle r (Snell's law). So let's measure the angles and look up the value of the function in the tables. Some applications of trigonometry are possible also in mechanical problems. We can do our pupils a service by keeping a little trigonometry bright.

Work out a problem in gas volume correction before the class using a slide rule. The fact that simple multiplication and division can be done quickly is worth demonstrating, and many pupils have never seen a slide rule in action.

Let's put an up-to-date touch in our problems. For example, calculate the hydrostatic pressure in an oil well drilling hole filled with colloidal drilling mud heavily loaded with barytes or hematite at a depth of 5,000 feet. Or, how many times will a bubble of CO_2 expand when in the process of acidifying an oil well with hydrochloric acid, sp. gr. 1.1, which fills the hole to a depth of 2,000 feet, it is generated by the action of the acid on calcite?

The technical men have rolled up their sleeves and we see the results. Electronic devices are used for both civil and military needs; sensitive relays (a device to which more attention should be given) act as controls; pipe lines are insulated on glass fiber and cathodically protected by counter E M F; benzoyl and nitroparaffins are used as combustion accelerators in Diesel fuel; superfractionators in the petroleum industry separate pure compounds from hydrocarbon mixtures; and it is reported that the amount of electronic heating (high frequency induction) used in one plastics factory alone exceeds the energy demand of our largest radio station.

III

A third point may be introduced by an anecdote. Two ladies and the daughter of one of them were dining at a wayside restaurant. The ladies each ordered a chicken dinner for two dollars. The little girl wanted a chicken dinner too, but her mother protested, saying that it was too expensive considering that she wouldn't eat all of it. "Here," said the mother, "is the menu.

You can read now, so you find something which is smaller and less expensive."

After a few minutes the little girl beamed and said, "Oh mother, here it is, 'Old Crow, twenty-five cents'."

The third point is, ***let's rise to our opportunities.*** Figures recently collected by a committee show an increase of about 3–4% between 1939–1943 in chemistry enrollment for 62 New England schools, public and private, responding out of 213. For the same period the increase in physics enrollment was 17%, while 67% of the schools have introduced aeronautics, 36% radio, 10% navigation, 7% communications, and 36% other war courses. We now have an audience for physics. We should not "let them down."

We can serve by helping our pupils save heat by teaching well the familiar principles of heat transfer, insulation, and the relationship of humidity to comfort in a room. The heat transfer formula $Q=K\ A\ (T_1-T_2)\ t/d$ can be developed by classroom discussion. Let's progress beyond the general science level in radiation, conduction, and convection.

Heat conductivity is extremely important in determining the rapidity with which substances reach their kindling temperatures. A fuzz-stick, each shaving insulated by air, catches fire when passed through a flame, but a solid piece of the same stick conducts heat and is much slower in reaching its kindling point.

The importance of fire in war and peace warrants more attention to the practical applications of physics to extinguishing fires.

(a) Oil fires are extinguished by a high-pressure spray of water, emphasizing the importance of water's high heat of vaporization in cooling the burning oil.

(b) Carbon tetrachloride also uses heat of vaporization when it changes from a liquid to a dense oxygen-excluding vapor.

(c) The cooling effect of subliming dry ice is also evident.

Captain Frederick Zehrer, U.S.A., of Boston stated in a letter that we should "provide practical, realistic instruction in order to develop skills—to really demonstrate principles and use equipment both inside and outside the classroom, use visual aids extensively, and really adjust our offerings to the varying abilities and backgrounds." In other areas specific inquiries about materials or preinduction training should be sent to the local chief of preinduction training. Certainly the army people

urge us to roll up our sleeves, to become alert, and to use apparatus extensively. Here the importance of reading instruments, knowing the limitations of instruments, the rapid use of verniers, and accuracy in recognizing units in scale subdivisions are obvious.

Practical water distillation apparatus is worth discussing, and some knowledge of ion-exchange resins with which some liferafts are now equipped is helpful. How to cool warm water, and how to cool the body when exposed to extreme heat are practical bits of helpful information.

We have an opportunity to improve our methods and our apparatus benefiting by our sudden prominence. It is well known that the properties of a substance all change if the temperature is changed even one degree. Yet there is no good way available at present to show a class the fact that the temperature changes in an experiment, except in a few cases. Also, wouldn't a few polystyrene or methyl-methacrylate transparent resin blocks be useful for measuring the index of refraction of these materials?

We have an opportunity to correct an impression about research. A certain junior high-school pupil was given a lesson on Pasteur. He copied a few lines from a book for his report, misspelling eight words. This was labeled research in the junior high school. Again, a recent issue of the *Scholastic* newspaper for high schools (October 19, 1943, Teachers' Guide issue) mentions the "social control of research" in an article which shows complete confusion between science, technology, and the military applications of scientific principles. As science teachers we must protect our subject even from its friends while decrying its misapplication for destructiveness.

A few weeks ago a chemistry teacher demonstrated the catalytic action of manganese dioxide in the decomposition of hydrogen peroxide. In discussing the experiment with a physics-teaching colleague the latter raised the question as to whether or not the effect was one which could be duplicated by any agent which increased the surface, chalk dust for example. Further experiments showed that this was not the case, but in making the suggestion he showed himself a good physics teacher, for he raised a doubt. It is our function as physics teachers to remove periods from the ends of sentences and to pave the way for more investigation. We readily recognize and teach that Hooke's law has its obvious limitations. By the same token why

should Boyle's law or Ohm's law be held as sacrosanct? Each describes a general trend with limited application.

To summarize, as physics teachers we can aid our country by doing an effective piece of work. This end can be aided by care of our apparatus and laboratories, by more and better pupil laboratory work. The ready-for-business attitude with hands and mind alert needs extension these days, and the opportunity for popularizing, modernizing, and actual practical teaching is unique to our subject.

A teacher made a remark in a chemistry class some years ago that every problem consists of a number of simpler problems. We should solve the simpler problems and put the solutions together. This somewhat routine remark stuck with one of his pupils. Its full force struck him during his second year of college when he "woke up," and later carried on a successful business career. When a certain New England town needed a leader to pull it out of a hole it was this same former pupil (not Washington) who solved the little problems and helped restore prosperity to a whole town most admirably.

So if when we go forward in the morning to stem the rising tide of ignorance we feel as alone and desperate in our task as did the Dutch boy in the story with his finger in the hole in the dike, remember that while the Dutch boy couldn't calculate the pressure on his finger or the total sideward force on the wall of the dike, he did stick to his job.

PRESIDENT ROOSEVELT ON THE JUNIOR COLLEGE

The significance of junior college terminal courses for returning service men and women was stressed by President Roosevelt in a special message which he sent to the American Association of Junior Colleges at its recent 24th annual meeting in Cincinnati. "The junior college," he wrote, "has now become a robust youngster in the family of American educational institutions. My particular interest at present centers in the part that the junior college may play in providing suitable education for many of the returning soldiers and sailors."

President Roosevelt emphasized the importance of the dual nature of such education—vocational and general. "These men and women," he continued, "will wish, in many cases, terminal courses which combine technical or other vocational preparation with courses which assure a basic understanding of the issues confronted by them as American and world citizens. It seems possible, therefore, that the junior college may furnish the answer to a good many of these needs."

In conclusion the President expressed the hope that the Association "at this critical time may devise ways of serving most effectively the needs of American education and especially the postwar needs of ex-service men and women."

DARWIN AND LINCOLN

Edward C. Colin
Chicago Teachers College, Chicago, Illinois

At all times and especially in trying times like the present we may well seek wisdom and inspiration in the lives of great men of the past. It is merely an interesting coincidence that Abraham Lincoln and Charles Darwin were born on the same day 135 years ago last February 12. It is an important and a cheering fact that in one year our species was able to produce two such noble examples.

In spite of differences in environment and training, Darwin and Lincoln were fundamentally alike in intellect and character. Although their labors were in different fields their ideals, attitudes, and even their methods of work were similar. Lincoln's career is proof of the fact that a statesman may approach his tasks in the true scientific spirit, while Darwin's life shows that a scientist of the first rank may also be a humanitarian.

Honesty, lack of prejudice, reliance upon reason rather than upon emotion in the solution of problems, modesty, a sense of humor, sympathy, the courage of one's convictions, ambition held in proper check—all of these are attributes of Lincoln the statesman and of Darwin the naturalist. The anniversary of their births seems a fitting occasion to reflect upon the traits which led to their remarkable achievements.

The characteristics of a man may be appreciated most truly from a study of the words and deeds of the man himself. The quotations[1] below, selected from the writings of Darwin and Lincoln, and arranged under appropriate headings, will, it is hoped, be found both interesting and profitable.

Love of Truth

Lincoln and Darwin loved the truth above all else, but without fanaticism. Neither showed any desire to win fame as a martyr; accordingly, they were willing to compromise on unimportant points. Both were idealists and at the same time

[1] All quotations from Darwin are (unless otherwise indicated) from *The Life and Letters of Charles Darwin, Including an Autobiographical Chapter*. Edited by his son Francis Darwin, 1887. Reprinted by D. Appleton and Company, 1896. All quotations from Lincoln except as noted are from *Abraham Lincoln: Complete Works*. Edited by John G. Nicolay and John Hay. New York: The Century Company, 1922. By the kind permission of the publishers.

eminently practical advocates. Each took great pains to present his ideas in a manner designed to win converts.

Darwin:

. . . I had at last [October, 1838] got a theory [Natural Selection] by which to work; but I was so anxious to avoid prejudice, that I determined not for some time to write even the briefest sketch of it. In June 1842 I first allowed myself the satisfaction of writing a very brief abstract of my theory in pencil in 35 pages . . .

. . . As far as I can judge, I am not apt to follow blindly the lead of other men. I have steadily endeavoured to keep my mind free so as to give up any hypothesis, however much beloved (and I cannot resist forming one on every subject), as soon as facts are shown to be opposed to it. Indeed, I have had no choice but to act in this manner, for with the exception of the Coral Reefs, I cannot remember a single first-formed hypothesis which had not after a time to be given up or greatly modified . . .

. . . I had, also, during many years followed a golden rule, namely, that whenever a published fact, a new observation or thought came across me, which was opposed to my general results, to make a memorandum of it without fail and at once; for I had found by experience that such facts and thoughts were far more apt to escape from the memory than favourable ones. Owing to this habit, very few objections were raised against my views which I had not at least noticed and attempted to answer.

—*Autobiography*, 1876.

Lincoln:

There is a vague popular belief that lawyers are necessarily dishonest. I say vague, because when we consider to what extent confidence and honors are reposed in and conferred upon lawyers by the people, it appears improbable that their impression of dishonesty is very distinct and vivid. Yet the impression is common, almost universal. Let no young man choosing the law for a calling for a moment yield to the popular belief—resolve to be honest at all events; and if in your own judgment you cannot be an honest lawyer, resolve to be honest without being a lawyer. Choose some other occupation, rather than one in the choosing of which you do, in advance, consent to be a knave.

—*Fragment. Notes for law lecture, July 1, 1850?*

Some men, mostly Whigs, who condemn the repeal of the Missouri Compromise, nevertheless hesitate to go for its restoration, lest they be thrown in company with the Abolitionists. Will they allow me, as an old Whig, to tell them, good-humoredly, that I think this is very silly? Stand with anybody that stands right. Stand with him while he is right, and part with him when he goes wrong.

—*Speech at Peoria, Illinois, in reply to Senator Douglas, October 16, 1854.*

Neither let us be slandered from our duty by false accusations against

us, nor frightened from it by menaces of destruction to the government, nor of dungeons to ourselves. Let us have faith that right makes might, and in that faith let us to the end dare to do our duty we as understand it.

—*Address at Cooper Institute, New York, February 27, 1860.*

. . . I shall try to correct errors when shown to be errors; and I shall adopt new views so fast as they shall appear to be true views . . .

—*Letter to Horace Greeley, August 22, 1862.*

Love of Logic

Both Lincoln and Darwin had complete faith in the power of reason, but they realized the fallibility of the human mind, and each for his own good made every effort to understand his opponents' points of view. Both were unexcelled in seeing all sides of a question and in fairly stating a case for argument.

Darwin:

. . . Again, in my last year [at Cambridge University] I worked with some earnestness for my final degree of B.A., and brushed up my Classics, together with a little Algebra and Euclid, which latter gave me much pleasure, as it did at school. In order to pass the B.A. examination, it was also necessary to get up Paley's "Evidences of Christianity," and his "Moral Philosophy." This was done in a thorough manner, and I am convinced that I could have written out the whole of the "Evidences" with perfect correctness, but not of course in the clear language of Paley. The logic of this book and, as I may add, of his "Natural Theology," gave me as much delight as did Euclid. The careful study of these works, without attempting to learn any part by rote, was the only part of the academical course which, as I then felt and as I still believe, was of the least use to me in the education of my mind. I did not at that time trouble myself about Paley's premises; and taking these on trust, I was charmed and convinced by the long line of argumentation.

—*Autobiography*

Lincoln:

He studied and nearly mastered the six books of Euclid since he was a member of congress [member 1846–1848].

—*Autobiography* [*in the third person*], June, 1860.

The Cooper Institute Speech is a classic example of Lincoln's power in the use of logic.

Masters of Psychology

Lincoln and Darwin were masters of the art of practical psychology.

Darwin:

. . . I rejoice that I have avoided controversies, and this I owe to Lyell,

who many years ago, in reference to my geological works, strongly advised me never to get entangled in a controversy, as it rarely did any good and caused a miserable loss of time and temper.

. . . My book on "Insectivorous Plants" was published in July 1875—that is, sixteen years after my first observations. The delay in this case, as with all my other books, has been a great advantage to me; for a man after a long interval can criticise his own work, almost as well as if it were that of another person. . . .

. . . I have as much difficulty as ever in expressing myself clearly and concisely; and this difficulty has caused me a very great loss of time; but it has had the compensating advantage of forcing me to think long and intently about every sentence, and thus I have been led to see errors in reasoning and in my own observations or those of others.

—*Autobiography*

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Lincoln:

When the conduct of men is designed to be influenced, persuasion, kind, unassuming persuasion, should ever be adopted. It is an old and a true maxim "that a drop of honey catches more flies than a gallon of gall." So with men. If you would win a man to your cause, first convince him that you are his sincere friend. Therein is a drop of honey that catches his heart, which, say what he will, is the great highroad to his reason, and which, when once gained, you will find but little trouble in convincing his judgment of the justice of your cause, if indeed that cause really be a just one. On the contrary, assume to dictate to his judgment, or to command his action, or to mark him as one to be shunned and despised, and he will retreat within himself, close all the avenues to his head and his heart; and though your cause be naked truth itself, transformed to the heaviest lance, harder than steel, and sharper than steel can be made, and though you throw it with more than herculean force and precision, you shall be no more able to pierce him than to penetrate the hard shell of a tortoise with a rye straw. Such is man, and so must he be understood by those who would lead him, even to his own best interests.

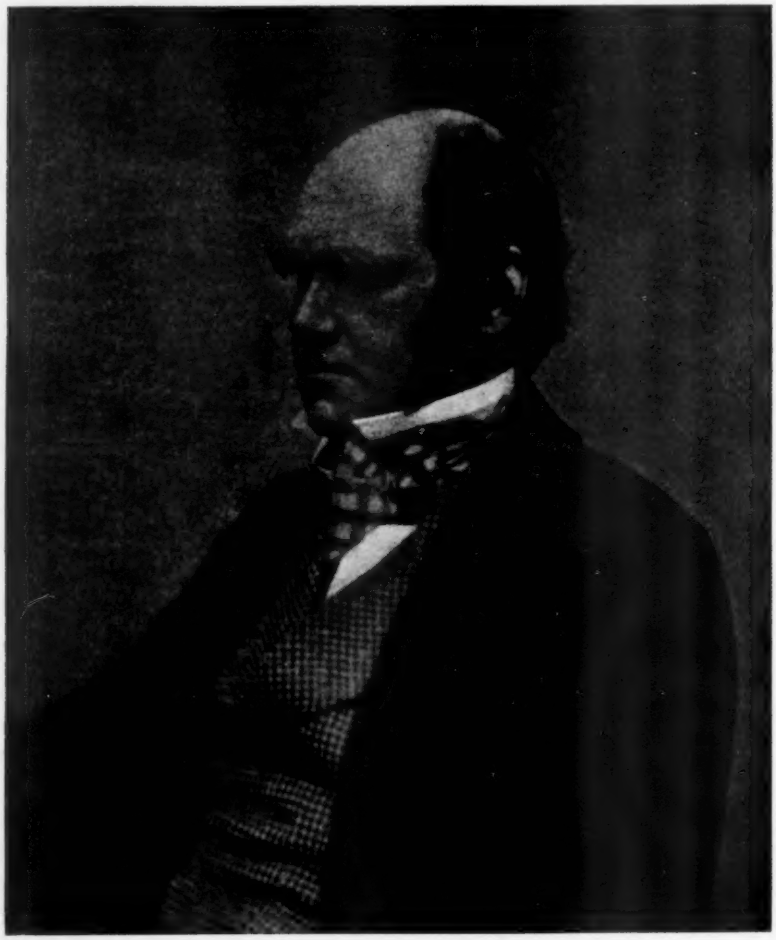
—*Address before the Springfield Washingtonian Temperance Society, February 22, 1842*

. . . If I have any chance, it consists mainly in the fact that the whole opposition would vote for me, if nominated. (I don't mean to include the pro-slavery opposition of the South, of course.) My name is new in the field, and I suppose I am not the first choice of a very great many. Our policy, then, is to give no offense to others—leave them in a mood to come to us if they shall be compelled to give up their first love. This, too, is dealing justly with all, and leaving us in a mood to support heartily whoever shall be nominated. . . .

—*Letter to Samuel Galloway, March 24, 1860.*

Love of Justice

Darwin and Lincoln had strong feelings of sympathy and love for their fellowmen, combined with hatred of injustice and cruelty. They both condemned the doctrine that might makes right. The institution of slavery in particular was most hateful



Charles Darwin in 1854
(From *Charles Darwin: A Portrait.* By Geoffrey West. 1938. Courtesy Yale University Press, New Haven.)

to them. In their own lives they shrank from inflicting unnecessary pain on anyone, but neither hesitated to do his duty as he

saw it even though such actions meant suffering to himself and others.

Darwin:

. . . I have watched how steadily the general feeling, as shown at elections, has been rising against Slavery. What a proud thing for England if she is the first European nation which utterly abolishes it! I was told before leaving England that after living in slave countries all my opinions would be altered; the only alteration I am aware of is forming a much higher estimate of the negro character. It is impossible to see a negro and not feel kindly towards him; such cheerful, open, honest expressions and such fine muscular bodies. . . .

—Letter to Miss C. Darwin, May 22, 1833.

It does one's heart good to hear how things are going on in England. Hurrah for the honest Whigs! I trust they will soon attack that monstrous stain on our boasted liberty, Colonial Slavery. I have seen enough of Slavery and the dispositions of the negroes, to be thoroughly disgusted with the lies and nonsense one hears on the subject in England. . . .

—Letter to J. M. Herbert, June 2, 1833.

He [Carlyle] has been all-powerful in impressing some grand moral truths on the minds of men. On the other hand, his views about slavery were revolting. In his eyes might was right. His mind seemed to me a very narrow one; even if all branches of science, which he despised, are excluded. . . .

—Autobiography

. . . Great God! how I should like to see the greatest curse on earth—slavery—abolished!

—Letter to Asa Gray, June 5, 1861.

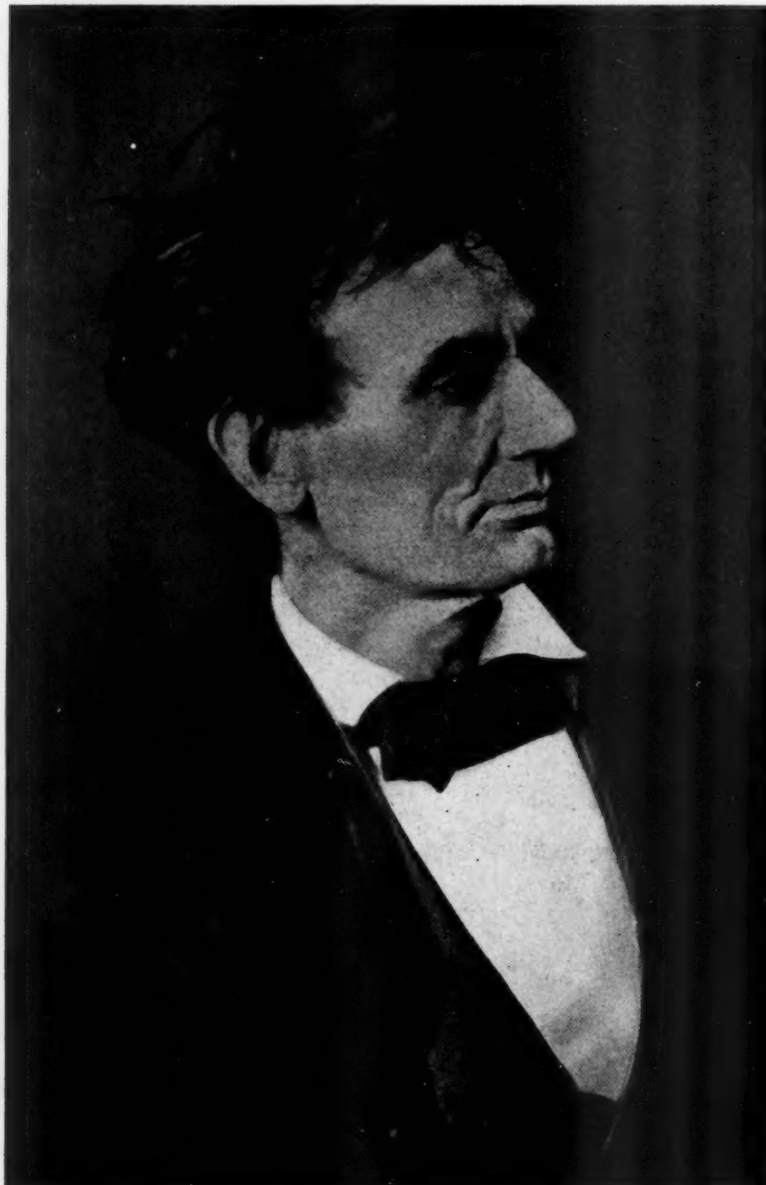
Lincoln:

Discourage litigation. Persuade your neighbors to compromise whenever you can. Point out to them how the nominal winner is often a real loser—in fees, expenses, and waste of time. As a peacemaker the lawyer has a superior opportunity of being a good man. There will still be business enough. Never stir up litigation. A worse man can scarcely be found than one who does this. . . .

—Fragment. Notes for law lecture, July 1, 1850.

This declared indifference, but, as I must think, covert real zeal, for the spread of slavery, I cannot but hate. I hate it because of the monstrous injustice of slavery itself. I hate it because it deprives our republican example of its just influence in the world; enables the enemies of free institutions with plausibility to taunt us as hypocrites; causes the real friends of freedom to doubt our sincerety; and especially because it forces so many good men among ourselves into open war with the very fundamental principles of civil liberty, criticizing the Declaration of Independence, and insisting that there is no right principle of action but self-interest.

—Speech at Peoria, Illinois, in reply to Senator Douglas, October 16, 1854.



Abraham Lincoln in 1857

(From *Lincoln: His Life in Photographs*. By Stefan Lorant. 1941. Duell, Sloan and Pearce, New York. Courtesy of the Author.)

. . . I have always hated slavery, I think, as much as any Abolitionist . . .

. . . Those arguments that are made, that the inferior race are to be treated with as much allowance as they are capable of enjoying; that as much is to be done for them as their condition will allow—what are these arguments? They are the arguments that kings have made for enslaving the people in all ages of the world. You will find that all the arguments in favor of kingcraft were of this class; they always bestrode the necks of the people—not that they wanted to do it, but because the people were better off for being ridden . . .

. . . Let us discard all this quibbling about this man and the other man, this race and that race and the other race being inferior, and therefore they must be placed in an inferior position. Let us discard all these things, and unite as one people throughout this land, until we shall once more stand up declaring that all men are created equal. . . .

—Speech at Chicago, Illinois, July 10, 1858.

. . . I have no purpose to introduce political and social equality between the white and the black races. There is a physical difference between the two, which, in my judgment, will probably forever forbid their living together upon the footing of perfect equality; and inasmuch as it becomes a necessity that there must be a difference, I, as well as Judge Douglas, am in favor of the race to which I belong having the superior position. I have never said anything to the contrary, but I hold that notwithstanding all this, there is no reason in the world why the negro is not entitled to all the natural rights enumerated in the Declaration of Independence—the right to life, liberty, and the pursuit of happiness. I hold that he is as much entitled to these as the white man. I agree with Judge Douglas he is not my equal in many respects—certainly not in color, perhaps not in moral or intellectual endowment. But in the right to eat the bread, without the leave of anybody else, which his own hand earns, he is my equal and the equal of Judge Douglas, and the equal of every living man.

—First joint debate with Douglas, at Ottawa, Illinois, August 21, 1858.

Lincoln was accused by Douglas of inconsistency in the statements quoted above, of cutting his speeches to fit the prejudices of the voters in the respective geographical regions of the state. Lincoln denied the accusation, but he did not attempt to show how the Chicago speech could be reconciled with the later statement. He might have stated that in his Chicago speech he was advocating an ideal stand on racial equality, whereas in the Ottawa speech he was announcing practical policies which he would support if elected to the United States Senate. Lincoln was a practical reformer who seized upon an attainable goal and hammered away at it rather than risk certain defeat by advocating distant objectives impossible of present realization.

In 1858 his major concern was to check the spread of slavery and to place it "where the public mind could rest in the belief that it was in the course of ultimate extinction." It is hard to believe that the author of the Emancipation Proclamation would have opposed, as President, the granting of equal political rights to the negroes, had he been permitted to live, or that he would have held to the generalizations of racial inferiority announced in 1858, had he been in possession of the biological knowledge available today.

Sense of Humor

Darwin and Lincoln both possessed and frequently gave expression to a kindly and delicious sense of humor, which in the case of each was as often directed at himself as at others. A fine sense of balance and proportion, which bears some relationship to a sense of humor, is evident throughout their writings.

Darwin:

... Novels which are works of the imagination, though not of a very high order, have been for years a wonderful relief and pleasure to me, and I often bless all novelists. A surprising number have been read aloud to me, and I like all if moderately good, and if they do not end unhappily—against which a law ought to be passed. A novel, according to my taste, does not come into the first class unless it contains some person whom one can thoroughly love, and if a pretty woman all the better.

—*Autobiography*

... I am at work at the second volume of the Cirripedia, of which creatures I am wonderfully tired. I hate a Barnacle as no man ever did before, not even a sailor in a slow-sailing ship. My first volume is out; the only part worth looking at is on the sexes of Ibla and Scalpellum. . . .

—*Letter to W. D. Fox, October 24, 1852.*

... Now for pleasanter subjects; we were all amused at your defence of stamp collecting and collecting generally. . . . But, by Jove, I can hardly stomach a grown man collecting stamps. Who would ever have thought of your collecting Wedgwoodware! but that is wholly different, like engravings or pictures. We are degenerate descendants of old Josiah W., for we have not a bit of pretty ware in the house.

... Notwithstanding the very pleasant reason you give for our not enjoying a holiday, namely, that we have no vices, it is a horrid bore. I have been trying for health's sake to be idle, with no success. What I shall now have to do, will be to erect a tablet in Down Church, "Sacred to the Memory, &c," and officially die, and then publish books, "by the late Charles Darwin," for I cannot think what has come over me of late; I always suffered from the excitement of talking, but now it has become

ludicrous. I talked lately $1\frac{1}{2}$ hours (broken by tea by myself) with my nephew, and I was ill half the night. It is a fearful evil for self and family.

—*Letter to J. D. Hooker, January 3, 1863.*

Lincoln:

I was not very much accustomed to flattery, and it came the sweeter to me. I was rather like the Hoosier with the gingerbread, when he said he reckoned he loved it better than any other man, and got less of it.

—*Reply to Douglas at Ottawa debate, August 21, 1858.*

If any personal description of me is thought desirable, it may be said, I am, in height, six feet, four inches, nearly; lean in flesh, weighing on an average one hundred and eighty pounds; dark complexion, with coarse black hair, and gray eyes—no other marks or brands recollected.

—*Letter to J. W. Fell, December 20, 1859.*

Some specimens of your soap have been used at our house and Mrs. L· declares it is a superior article. She at the same time protests that I have never given sufficient attention to the "soap question" to be a competent judge.

—*Letter to Prof. Gardner, September 28, 1860.*

(From *Complete Works of Abraham Lincoln*, Nicolay and Hay. New York: Francis D. Tandy Co., 1905.)

Simplicity and Modesty

Both Lincoln and Darwin were simple and unpretentious in their relations with others, modest in estimating their own worth and work, but generous in their praise of the work and worth of others.

Darwin:

. . . I shall be *intensely* curious to hear what effect the book [*Origin of Species*] produces on you. I know that there will be much in it which you will object to, and I do not doubt many errors. I am very far from expecting to convert you to many of my heresies; but if, on the whole, you and two or three others think I am on the right road, I shall not care what the mob of naturalists think. . . .

—*Letter to T. H. Huxley, October 15, 1859.*

A distinguished zoologist, Mr. St. George Mivart, has recently collected all the objections which have ever been advanced by myself and others against the theory of natural selection, as propounded by Mr. Wallace and myself, and has illustrated them with admirable art and force. When thus marshaled, they make a formidable array; and as it forms no part of Mr. Mivart's plan to give the various facts and considerations opposed to his conclusions, no slight effort of reason and memory is left to the reader, who may wish to weigh the evidence on both sides. . . . My judgment may not be trustworthy, but after reading with care Mr. Mivart's book, and

comparing each section with what I have said on the same head, I never before felt so strongly convinced of the general truth of the conclusions here arrived at, subject, of course, in so intricate a subject, to much partial error.

—*The Origin of Species, Sixth edition, 1872.*

. . . My success as a man of science, whatever this may have mounted to, has been determined, as far as I can judge, by complex and diversified mental qualities and conditions. Of these, the most important have been —the love of science—unbounded patience in long reflecting over any subject—industry in observing and collecting facts—and a fair share of invention as well as of common sense. With such moderate abilities as I possess, it is truly surprising that I should have influenced to a considerable extent the belief of scientific men on some important points.

—*Autobiography.*

Lincoln:

. . . I must in candor say I do not think myself fit for the presidency. I certainly am flattered and gratified that some partial friends think of me in that connection; but I really think it best for our cause that no concerted effort, such as you suggest, should be made. Let this be considered confidential.

—*Letter to T. J. Pickett, April 16, 1859.*

. . . I must say I do not think myself fit for the presidency. As you propose a correspondence with me, I shall look for your letters anxiously.

—*Letter to S. Galloway, July 28, 1859.*

Herewith is a little sketch, as you requested. There is not much of it, for the reason, I suppose, that there is not much of me. If anything be made out of it, I wish it to be modest, and not to go beyond the material. . . .

—*Letter to J. W. Fell, December 20, 1859.*

. . . Holding myself the humblest of all whose names were before the convention, I feel in especial need of the assistance of all; and I am glad—very glad—of the indication that you stand ready.

—*Letter to S. P. Chase, May 26, 1860.*

. . . It is true that, while I hold myself, without mock modesty, the humblest of all individuals that have ever been elevated to the presidency, I have a more difficult task to perform than any one of them.

—*Address to the Legislature of New York, at Albany, February 18, 1861.*

Ambition

Lincoln and Darwin were driven by lofty ambitions to contribute to the welfare and true progress of their fellowmen, and both disdained the temporary fame and profit to be gained by playing up to the fashions of the hour.

Darwin:

. . . You do me injustice when you think that I work for fame; I value it to a certain extent; but, if I know myself, I work from a sort of instinct to try to make out truth.

—*Letter to W. D. Fox, March 24, 1859.*

During my last year at Cambridge, I read with care and profound interest Humboldt's "Personal Narrative." This work, and Sir J. Herschel's "Introduction to the Study of Natural Philosophy," stirred up in me a burning zeal to add even the most humble contribution to the noble structure of Natural Science. . . .

As far as I can judge of myself, I worked to the utmost during the voyage from the mere pleasure of investigation, and from my strong desire to add a few facts to the great mass of facts in Natural Science. But I was also ambitious to take a fair place among scientific men,—whether more ambitious or less so than most of my fellow-workers, I can form no opinion. . . . I think that I can say with truth that in after years, though I cared in the highest degree for the approbation of such men as Lyell and Hooker, who were my friends, I did not care much about the general public. I do not mean to say that a favourable review or a large sale of my books did not please me greatly, but the pleasure was a fleeting one, and I am sure that I have never turned one inch out of my course to gain fame.

—*Autobiography.*

Lincoln:

Every man is said to have his peculiar ambition. Whether it be true or not, I can say, for one, that I have no other so great as that of being truly esteemed of my fellow-men, by rendering myself worthy of their esteem.

—*Address to the people of Sangamon County, as a candidate for Representative in the General Assembly of the state, March 9, 1832.*

I cannot fly from my thoughts—my solicitude for this great country follows me wherever I go. I do not think it is personal vanity or ambition, though I am not free from these infirmities, but I cannot but feel that the weal or woe of this great nation will be decided in November.

—*Interview with John T. Mills, August 15, 1864.*

CONCLUSION

During the summer of 1858 Darwin began the writing of his greatest work, *The Origin of Species*, published November 24, 1859; while Lincoln, as a candidate for the United States Senate, was carrying on his famous debate on the slavery question with his opponent, Stephen A. Douglas. In the writings of Lincoln there is apparently no reference to Darwin or to evolution as such, but from internal evidence it is clear that Lincoln had the true evolutionary point of view respecting the progress of human

society. Whether Lincoln knew of Darwin's existence is an open question. Darwin, it seems, nowhere refers to Lincoln by name. His failure to do so is a bit strange, since he followed with interest the Civil War, as reported in the *London Times*, and discussed it in his correspondence with the Harvard botanist Asa Gray. From a comment in one of his letters to Gray it is evident that what he read in the newspapers made him distrustful of "the men of Washington," as he referred to the Federal Administration.

Both Darwin and Lincoln, like many another prophet of a new day, were hated intensely in their own time by those who misunderstood them or feared the effects of new ideas. Darwin, unlike Lincoln, was permitted to live out his life (he died at 73); but if words could have slain him he would have been killed many times for saying what he believed to be the truth.

Lincoln the statesman set free men's bodies, and in so doing brought nearer to realization the ideal of judging every man according to his own worth. Darwin the naturalist set free men's minds from enslaving dogmas of the past, and thus laid a firm foundation for the future grand progress of mankind. People today who are not bound by acquired prejudices and who are willing to study for themselves the works of these two great democrats cannot fail to be impressed by the immeasurable store of wisdom and inspiration which they have bequeathed to us.

NEW STANDARD FOR QUARTZ CRYSTALS

New standards for quartz crystals, used in aircraft radio equipment for the control of frequency or radio wavelength, have just been approved here by the American Standards Association, a federation of national groups dealing with standardization. The new standards will coordinate American, Canadian and British practice in making aircraft crystal units.

Quartz crystals, called the heart of the radio transmission system, are used to maintain frequency stability and minimize frequency interference. They control the wavelengths of messages sent out over the air. The supply is scarce; most of the good crystals are obtained from Brazil. They are extremely delicate and great care must be taken in cutting the rough quartz crystal blocks found in nature to obtain the wafer-like sections used in the radio field.

Among methods used in cutting radio quartz crystals is one developed recently by Dr. E. D. Tillyer of the American Optical Company, reported now to be widely used by radio manufacturers. He found that by cutting them with one face parallel to an electrical axis of the mother crystal, a technique exactly opposite from the previous method, he was able to produce crystals said to control radio transmission with greater efficiency and constancy.

NOTES ON APPROXIMATE COMPUTATION

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Despite the recommendations of various professional associations, the topic of approximate computation has received little consideration in secondary mathematics. An examination of the popular algebra and general mathematics texts indicates that it is treated, if at all, in isolation, earlier and later computations being performed without reference to possible approximate nature of data involved. An understanding of approximation would appear indispensable in selecting trigonometric tables, checking solutions, using logarithms, and appreciating mil measurement and other military applications, but among nine trigonometry texts recently examined by the writer only six included the topic, only three of the six attempted to rationalize linear and related angle accuracy, only two of the three provided exposition adequate for later applications, and only one of the two provided answers to exercises consistent with the exposition.

There appear to be several reasons for teacher and text neglect of approximate computation. The majority of teachers have had little acquaintance with the subject and are reluctant to abandon, regardless of data, the arbitrary convention of expressing answers "correct" to tenths, hundredths, etc. The literature dealing with the subject is neither consistent nor definite. In some cases the student is advised that one place beyond the smallest subdivision of the common measuring instruments may be estimated with a possible error of ± 1 in the last figure; in others, the student is warned that measurements should never claim greater precision than the instrument and should therefore be reported in terms of the smallest unit of the scale with a possible error of $\pm\frac{1}{2}$. The treatment of zeros is, in general, inadequate for even elementary application. So far as the literature is concerned, the zeros in a measurement of, say, 600 cm. are as likely to be insignificant as those in 186,000 miles. The statistical term *probable error* frequently is used synonymously with *possible error*, and there is conflicting use of the terms *precision*, *accuracy*, and *significant figures*. The following statements are representative.

> Figures which are necessary to indicate precision . . . are called significant figures.

Unlike the precision of a measurement . . . its accuracy . . . is dependent upon the number of significant digits in the measurement.

Only the first doubtful figure and those preceding it are significant.

The result of any arithmetical process will only be as accurate as its least accurate number.

Like Carroll's Humpty Dumpty, we may of course use words to mean exactly what we choose them to mean, neither less nor more, but we will find it impossible to build up an objective and useful body of literature on that basis. If precision is to mean the same thing as accuracy, it will be necessary to find another term to indicate relative size of the units of measurement. In the personal use of measurements, it will make no difference what sort of scheme we employ for reading the scale, and we may change from one scheme to another freely; in reporting measurements for the use of others and in interpreting given data, it will of course be necessary to employ a standard convention.

It has been rather widely recommended that approximate computation be taught in general mathematices and algebra. In the opinion of the writer, there are few subjects in school to which the topic is less suited. The former subjects are concerned primarily with basic skills and mathematical theory, and only academic use is made of the results of computation. It may be that the topic should be included at the expense of less practical material, but before undertaking such a change it is well to reflect that content reorganization in secondary mathematics has, to date, been rather completely unsatisfactory. The attempts to include consumer statistics in elementary algebra, for example, have resulted in a hodge podge of material resembling neither algebra nor statistics. As a matter of speculation, consumer statistics might better be taught in the social sciences, since in these subjects statistical data may have bearing on the problem at hand and since even the most elementary rigorous treatment of statistics is far too difficult for high school mathematics.

For similar reasons, the other branch of approximation, that dealing with physical measurements, might better be assigned to the subjects in which measurement and the results of computation are stressed rather than the "why" of the mathematical processes involved. Actual experience with approximate numbers is necessary before the definitions and rules can be understood and wisely used. As Campenella observed several hundred years ago, definitions are the beginning of teaching but they are not the beginning of knowing.

Among the subjects better suited to approximate computation are shop, trigonometry, and physics, the latter two in particular being ideally adapted to approximate number theory. In them, the questions of how far to carry out answers and what constitutes standards of accuracy are constantly arising. The student needs to know when the use of three or four place tables and the slide rule is justified. He needs to know why the sum of clockwise moments rarely equals the sum of counterclockwise moments, why the pressure-volume constant of a gas is never quite constant, and why a triangle usually fails to have 180° in a trigonometric check. Although some of the claims of the approximation enthusiasts regarding the great value of the topic may be exaggerated, it is obvious that the student of physics or trigonometry needs to understand the meaning of accuracy, significant figures, precision, and possible and per cent error.

Elementary treatment of approximate computation may well include a comparative history of measurements beginning with those which had their origin in human anatomy and activity, such as foot and fathom, and ending with such precision units as thousandth-inch. Emphasis should of course be placed upon the approximate nature of all measurement, even the most precise, and the practical difficulty of obtaining sufficiently accurate instruments for precision work. The approximate nature of decimal expressions of the mathematical processes which cannot be performed evenly, such as $\sqrt{2}$, π, $\frac{2}{3}$, etc., and of the numbers in most mathematical tables should also be stressed.

It is necessary that the student understands that measurements are reported or interpreted to the nearest unit used and that, except for uncertainty in the last digit a measurement must be demonstrably accurate as far as it goes. Emphasis should be placed upon the use of decimal points and zeros as a shorthand method of describing the unit used, i.e., the relative precision of the measurement. A reported measurement of 35.6 inches, for example, implies that the unit used is tenth-inch; one of 186,000 miles, thousand-miles. These facts are so obvious to the teacher that he may forget the student, usually thinking in terms of the one-units, fails to comprehend the implications of zeros and decimal points.

In addition to understanding the nature of measurements, the student needs to be able to identify the purpose of a measurement. If it is reported as data for a problem dealing with the application of principle, it makes little difference to what degree

of accuracy the computation is performed so long as the treatment is consistent. If it is made or reported in order to discover a fact or to support an opinion, however, it is necessary that no more accuracy be claimed than may be mathematically demonstrated. The student also should recognize that figures read out of context or interpreted without reference to their purpose are likely to be meaningless or misleading. Although taken from another field, a vivid example of this appeared in a recent issue of *Time*.

> After a tough struggle with its mountain of statistics, the U. S. Bureau of Labor Statistics formally brought forth the minutest statistic of the week: from mid-June to mid-July, the cost of living for city workers went down 0.8%. Secretary of Labor Frances Perkins emerged from the cabinet morgue to find this droplet impressive. Her reaction to statistics varies. When 0.5% of the nation's man-days of labor were lost by strikes in 1942, Miss Perkins had dismissed the figure as insignificant.

When the "minute" statistics are considered in context, Secretary Perkins' reaction appears to be considerably more sound than that of *Time's* clever reporter. Quite often, the most important question relating to a measurement is, "Why was it made?"

The student must learn to use judgment in handling approximate numbers and should form the habit of checking his decisions relative to "carrying out" and "rounding" with the old rule: *A measurement must be accurate as far as it goes and it should go far enough to express the desired degree of accuracy; hence, no more figures should be written than are known to be correct, and no figures which are known to be correct should be suppressed.*

After the student understands the nature and purpose of various sorts of approximate numbers and has reason for using them, the following set of suggestions and definitions will prove adequate for most situations in physics, the majority of which will of course apply to trigonometry as well.

1. The degree of accuracy of a measurement is determined by the ratio of the possible error to the measurement. This ratio or relative error, expressed as a per cent, is the per cent error. The relative error may always be found, if it is is agreed to report and interpret measurements with a possible error of $\pm \frac{1}{2}$ in the unit used, by dividing $\frac{1}{2}$ by the number of units in the measurement. Thus accuracy may be roughly estimated at a glance. (See Table II.)

2. Significant figures are the figures which tell (a) the number of units in a measurement and/or (b) the limits between which the true measurement lies. Zeros are significant when they serve those functions; they are not significant when they merely indicate the size of the unit, i.e., the relative precision of the measurement. More technically, zero is not significant if its function, were the measurement expressed as a logarithm,

would be only that of indicating the characteristic. Two-figure accuracy implies the use of two significant figures in a measurement; three-figure accuracy, three significant figures, and so on.

3. Measurements having the same significant digits, similarly ordered, have the same degree of accuracy. Thus, .00186, .186, and 186,000 have the same degree of accuracy. (See Table I.)

4. The per cent error of measurements containing only one significant figure may range from 50% to 5.5%; two significant figures, from 5% to .5%; three significant figures, from .5% to .05%. Three-figure accuracy is generally sufficient for physics except in rare cases when the measurement falls near the lower portion of the range of three figure numbers and when considerably lower than .5% error is desired. (See Table II.) In most cases, the use of zeros in reporting measurement is not intended to result in an interpretation of less than three-figure accuracy.

5. In the addition or subtraction of approximate numbers of varying degrees of precision, it usually is satisfactory to round off the more precise numbers until none contain more than one digit to the right of the terminal digit of the least precise number and then round one more digit in the sum or difference. In more precise addition, it may give slightly more accurate results to subtotal groups according to degree of precision and then add subtotals as suggested above.

6. In multiplying or dividing approximate numbers, the more accurate factor, divisor, or dividend may be rounded off until it contains only one more significant digit than the least accurate. After the multiplication or division is performed, the product or quotient usually should be rounded off until it contains only as many significant digits as the least accurate factor. Occasionally it is more satisfactory to estimate per cent errors in products and quotients before rounding off according to rule. If the least accurate number in the process falls in the upper portion of the range of its class, the retention of an additional digit in the answer may be justified.

Many of the conventions of approximate computation may be brought together and developed in tabular form. An organi-

TABLE I. THE NATURE AND ERROR OF MEASUREMENTS

Measurement	Limits between which the true measurement lies	Significant figures	Possible error	Per cent error
8 mm.	$7\frac{1}{2}$–$8\frac{1}{2}$ millimeters	8	$\frac{1}{2}$ unit	6%
2.4 lbs.	$23\frac{1}{2}$–$24\frac{1}{2}$ tenth-pounds	2, 4	$\frac{1}{2}$ unit	2%
6.00 m.	$599\frac{1}{2}$–$600\frac{1}{2}$ hundredth-meters	6, 0, 0	$\frac{1}{2}$ unit	.08%
97,000 cu. ft.	$969\frac{1}{2}$–$970\frac{1}{2}$ hundred-cubic-feet	9, 7, 0	$\frac{1}{2}$ unit	.05%
.0255 ft.	$254\frac{1}{2}$–$255\frac{1}{2}$ ten-thousandth-foot	2, 5, 5	$\frac{1}{2}$ unit	.2%
255 ft.	$254\frac{1}{2}$–$255\frac{1}{2}$ feet	2, 5, 5	$\frac{1}{2}$ unit	.2%

zation of work similar to that of Table I will prove of value in teaching the implications of precision, significant figures, and accuracy.

TABLE II. SIGNIFICANT FIGURES AND CORRESPONDING RANGES OF ERRORS

Examples of measurement	Unit used	Significant figures	Range of measurement	Possible error	Per cent error
1 foot .006 liter 9,000 miles	one-foot thousandth-liter thousand-miles	1 6 9	1 unit to 9 units	½ unit	50% to 5.5%
10 inches 2,500 cu. yds. .99 gram	one-inch hundred-cu. yds. hundredth-gram	1, 0 2, 5 9, 9	10 units to 99 units	½ unit	5% to .5%
100 mm. 2.54 cm. 99.9 pounds	one-millimeter hundredth-cm. tenth-pounds	1, 0, 0 2, 5, 4 9, 9, 9	100 units to 999 units	½ unit	.5% to .05%

It is desirable that the student recognizes the range of error in one-, two-, and three-figure measurements and that he learns to estimate accuracy roughly at a glance. Table II summarizes the error possibilities for the three degrees of accuracy.

The conventions of approximate numbers make it possible to establish objective standards of accuracy in elementary physics. In problems involving given data, computations will be simplified and answers made to agree by application of suggestions 5 and 6, above. More than three-figure accuracy is rarely justified.

In laboratory exercises and experiments, in which the only uncontrollable source of error is measurement, the actual per cent error should be no greater than the possible per cent error. It cannot be expected, of course, to verify physical constants and properties with accuracy exceeding that which the precision of the measuring instruments establish. It would not be expected, for example, to verify in the elementary physics laboratory the fact that the density of aluminum is 2.699. In exercises designed to verify physical laws, such as Boyle's law or the law of machines, it cannot be expected to find the products agreeing beyond three significant figures at best. The most logical standard of accuracy in such exercises is established by the practice of accepting no discrepancies which cannot be reconciled on the basis of the possible errors of the measurements.

Adequate treatment of elementary computation demands considerable thought and follow through on the part of the teacher, but the topic, if handled in realistic setting, is not difficult. In view of the fact that it will enable the student to answer many of his own questions regarding precision and accuracy, it appears to be worth the time and effort.

ENERGY AND WAR*

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When one has a house built he expects to pay for materials and for labor—for matter and energy. Although less tangible, the energy is as much of an entity as the matter. "Without matter nothing exists, without energy nothing happens." The lifting of a weight requires the expenditure of human energy. When the Romans, in their wars of conquest, took thousands of prisoners, they put them to enforced labor of the most arduous kind. At Baalbek, on the plains of Syria there can be seen colossal ruins in which blocks of stone weighing 1,500 tons each are located 30 feet above the level of the ground. These were cut in quarries several miles away, were transported and raised to their place largely by human effort. Probably some simple machines were employed. Machines serve several general purposes. They may make the task easier, as in the case of a one-ton automobile jack (1) by means of which even a small child can lift one end of a car. A machine may give increased speed, as illustrated by the bicycle. In some cases a machine is able to do a certain job better than man can do it by the skill of his hand. For centuries, needles were hand-made, but machine-made needles are not only made a thousand times faster but they are more uniform in shape, size and quality.

It should be noted that, in no case does a machine supply its own energy. The auto jack is powerless, of itself to lift the car. Fortunately, Nature provides sources of energy in generous quantities which can be utilized by machines. The water wheel was first used just prior to the beginning of the Christian era and the energy of falling water was set to doing useful tasks such as

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* A popular lecture delivered on December 10 at the New England Museum of Natural History and illustrated by materials and films listed at the end of this report.

the grinding of grain. Centuries later steam and electrical energy were harnessed. Today we are in the midst of the gasoline era. The combined power from the burning of coal, the falling of water and from work animals adds up to only 15% of the total used in this country, while gasoline provides 85%. It has been calculated that Americans consume more gasoline than drinking water.

The oldest, and in many ways the best of all machines is the human body. Strictly speaking, it is not *a machine* but an aggregation of machines comparable to a power plant and factory. It is capable of doing an amazing variety of things which no other machine can accomplish. It has parts that are so delicately constructed and adjusted that they can not even be duplicated by the most skilled technician. Unlike all other machines, it is capable of self-repair and self-direction. Since it does work it possesses energy, but this energy is not self-created; it must be supplied from without. Bacon, potatoes, sugar, soy beans and other energy foods serve as fuel for the human engine. Some physiologist has stated that when a typist eats one peanut, it provides her with the energy required to type 1,000 words.

The human body is a wonderfully ingenious mechanism but its capacity for doing work is very limited, in fact, pitifully small as compared with modern machinery. The diminutive gasoline engine (2) of $\frac{1}{8}$ horse power which is used to propel a toy model airplane can do more work than a strong working man who saws wood or shovels coal. The engine of an automobile is equal in energy output to 500 men. One cylinder of a Pratt and Whitney Wasp engine is equal to the entire engine of an automobile, but there are 18 cylinders in the entire airplane engine. Four such engines give a B-24 plane, energy equivalent to that of 35,000 men. On a wall in one of America's largest factories there is painted in large letters, this significant statement, "It is wrong to ask a man to do any job that can be done by a machine." Why is it economically wrong? A worker who toils incessantly during working hours of a 48-hour week in America certainly expects to receive as much as $20 and this adds up to over $1,000 per year. The humble little kitchen mixer (3) will do more work than the man and the electrical energy required to operate it for a year costs about $12.

It has been calculated that one half of all the world's work is done in America, but not as manual labor. It is as though every man and woman in this country had 100 slaves to command.

The steam engine provides energy for driving machinery in many factories but it does not create this energy. Superficially, specimens of lava, obsidian and coal (4) are similar in appearance. The first two are of little value but the coal is a precious stone, intrinsically of much greater value than a diamond. When purchasing coal, one is not interested in its physical properties. Coal is primarily a source of energy and the coal dealer is essentially a purveyor of energy. Coal is sometimes called "canned sunshine" because its energy was given by the sun, to growing vegetation during the Carboniferous Period of geological history. If all of its energy could be utilized a pound of coal (5) might do the work of a man for three hours.

Gasoline is also a vast reservoir of potential energy. A gallon of it (6) costing perhaps 20 cents, contains as much energy as a hard-working man could deliver in a whole year's work. A pound of gasoline contains more energy than a pound of gun powder, a pound of dynamite or a pound of T.N.T. One naturally wonders, then, why coal and gasoline are less destructive in action than the three explosives mentioned. A cracker contains potential energy, but it burns slowly in air and still more slowly in the human body. Potassium chlorate contains oxygen but it, of itself will not burn. If the cracker is pulverized in a mortar and mixed with powdered potassium chlorate (7) it burns readily with a hot flame. It has become, in effect, an explosive, for the cracker and the oxygen needed for for its combustion are both contained in the mixture.

Methods of warfare have undergone marked change during the span of human history. Once it was a stuggle of man against man, a personal conflict with hands, clubs or swords, human energy matched against human energy. Now, it often happens that a man kills another whom he does not even see. By the pressing of a button or the pulling of a trigger, he releases energy exceeding that of a thousand men.

Energy is required to build a structure, energy may be used to destroy it. A 2-ton bomb in a few second reduces to shapeless rubble, a structure which weighed many tons and which was erected at the cost of much energy. In the present stage of this world conflict one can envisage a prodigious quantity of energy in the form of explosives, gasoline, fuel oil and food, flowing outward from America to the remote parts of the globe, and it is evident that very little of this energy will ever be returned to us.

Professor Mather of Harvard has pointed out that Nature

can, on occasions, be cruel and relentless. Earthquakes, volcanoes, tornadoes, tidal waves and floods are manifestations of her destructive energy. But these are not common occurrences, their effects are usually not wide-spread and the number of lives taken by them is not large in relation to the total population of the world. From the geologist's point of view the human species might maintain a comfortable existence for an indefinitely long period of time. Man need not fear Nature but he may well fear his own kind. A prolonged war, waged with such unprecedented quantities of energy as we can now command might result in the practical extinction of those peoples who have contributed most to human progress. It is conceivable that the race may commit suicide.

Illustrative Materials and Films

(1) Automobile Jack
(2) $\frac{1}{5}$ H.P. Gasoline Engine for Model Airplane
(3) Electric Kitchen Mixer
(4) Specimens of Lava, Obsidian, Coal.
(5) Lump of Coal Weighing One Pound.
(6) One Gallon Bottle of Gasoline.
(7) A Cracker and Potassium Chlorate

Lecture followed by the showing of ERPI sound films,
Fuel and Heat
Energy and its Transformations.

SCIENTISTS MAY ENLIST YEAST CELLS TO MANUFACTURE VITAMIN CHEMICAL, BIOTIN

Micro-organisms, already used to produce disease-fighting substances of which the most famous example is penicillin, may next be enlisted by scientists for manufacture of a vitamin chemical, biotin. This possibility is suggested in a report to Science by Prof. Vincent du Vigneaud, Dr. Karl Dittmer and Dr. Donald B. Melville, of Cornell University Medical College.

Biotin is necessary for the growth of yeast and other microorganisms. Its role in human nutrition is not definitely known but once more ample supplies of the vitamin are available, this knowledge may be gained.

Synthesis of biotin in the laboratory has been achieved following elucidation of its structural formula by Prof. du Vigneaud and associates. More recently they have prepared from biotin another chemical, desthiobiotin, which also promotes the growth of yeast and some but not all the other microorganisms whose growth is promoted by biotin. In fact, at certain concentrations, desthiobiotin was found to have an anti-biotin effect for one such organism, Lactobacillus casei.

Growing yeast cells, they now report, can apparently convert desthiobiotin into biotin. Since desthiobiotin can be synthesized more easily than biotin in the laboratory, they suggest that yeast or some other microorganism which can convert larger amounts of desthiobiotin to biotin may be used for more easily obtaining supplies of biotin itself.

SOME PROBLEMS IN TIN CONSERVATION

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Tin supply and tin conservation have become topics of increasing popular interest during the past three and one-half years. Much has been said or written about these two important subjects from a variety of standpoints or interests. However, apart from the discussions of Lueck (1), Brighton (2), Cameron (3), and Stewart and Pilcher (4), little attention has been devoted either to problems in tin conservation from the standpoint of the can manufacturer or to the basic plan of the current conservation program.

Tin conservation has been in effect officially since 1941 and was first inaugurated as one of the essential activities in the National Defense Program. Since that time many additional conservation measures have been instituted after test and experiment have shown that these new measures were feasible or practical. In work of this type, a great part of the responsibility has been assigned by official agencies to the research and development departments of can manufacturers. In such work, the graduates of many of the institutions represented by the membership of this section have been active and in many instances have made substantial contributions. It is the purpose of this discussion to review briefly the plan of the present program and as time will permit, to indicate the progress made on certain of its technical problems referred to our laboratory by official agencies.

The Current Tin Conservation Program

Peacetime Supplies and Uses of Tin

A better understanding of the basic problems involved in the present conservation program may readily be obtained by consideration of American peacetime tin supplies and usages. In Table 1 are given statistics for world production of tin in 1940, by chief ore producing localities. As will be noted, based on past production, nearly 80 per cent of our normal sources of tin are now in the temporary possession of the Japanese. In particular, the major producing areas of Malaya and the Netherlands East Indies are at the moment solidly under Jap control. Of those

sources normally available, only Bolivia, the United Kingdom whose Cornwall mines were first worked by the ancients, and the ore-producing localities in Africa now remain open for Allied use.

TABLE 1. WORLD PRODUCTION OF TIN*
(1940)

Locality	Tin Production
	Long Tons
Malay States & Straits Settlements	85,384
Netherlands East Indies	44,447
Bolivia	37,940
Thailand	17,447
Nigeria	10,257
Belgian Congo	12,392
China	6,349
Burma	5,500
United Kingdom	1,800
Argentina	1,600
French Indo-China	1,560
Other Countries	10,078
	234,754

* Adapted from *Statistical Bulletin*, Tin Research Institute, November, 1941.

In Table 2, the amounts of tin consumed domestically in 1937, an average peacetime year, are shown according to former usage. It will be immediately noted that of the 90,130 long tons of the metal, 60,476 went into the manufacture of tin plate, terne plate and solder. The largest single item listed is the 39,221 tons of tin used in the manufacture of tin plate. This use accounted for nearly 44 per cent of the tin consumed in that year. The data shown in these figures illustrate two inescapable facts which have conditioned current, official tin conservation. First, in conservative planning, America should not depend upon receiving more than a small fraction of the tin imports she formerly enjoyed. Second, to conserve the national stockpile of tin, carefully built up by increased imports prior to Pearl Harbor (1), there should be a substantial reduction in the amounts of the metal allocated to the manufacture of tin plate and solder. It is perhaps unnecessary to state that such drastic conservation steps should be applied to vital materials like tin plate and solder only after less essential domestic uses of tin have been eliminated entirely, and such actually has been the case. In this connection, many will recall the restrictions placed on the use of tin

TABLE 2. AMOUNTS OF TIN CONSUMED IN DOMESTIC USES*
(1937)

Use	Amount of Tin in Long Tons		
	Primary Tin	Secondary Tin	Total
Alloys, Miscellaneous	482	24	506
Babbitt Metal	4,501	2,272	6,773
Bar Tin	652	174	826
Bronze	3,712	2,784	6,496
Chemicals	171	1,331	1,502
Collapsible Tubes	3,571	—	3,571
Foil	1,456	4	1,460
Galvanizing	997	—	997
Pewter & White Metals	374	33	401
Solder	12,026	7,832	19,858
Terne Plate	382	1,015	1,397
Tinning	2,585	67	2,652
Tin Oxide	793	411	1,204
Tin Plate	39,221	—	39,221
Tubing, Solid	1,278	18	1,296
Type Metals	221	1,140	1,361
Other Uses	506	97	603
Grand Totals	72,928	17,202	90,130

* Adapted from National Academy of Sciences Report on Tin, 1941.

in certain commodities early in 1941, for example, restriction of tin in collapsible tubes used for pastes or creams.

Obviously, reduction in the use of tin can be effected either by restricting the manufacture and/or use of tin plate and solder, or by seeking substitutes for them which will not require the use of tin or which will require the use of less tin than formerly, or by both. Needless to state, these conservation measures should be applied in such a manner as to dislocate to the minimum extent our economic balance, as well as in such a way as to permit application of our fullest military effort in the current war. Cognizance of all these considerations has been taken by official agencies in the present tin conservation program.

Orders M-81 and M-43

The first official steps to conserve tin were taken by the late Office of Production Management after its creation in the summer of 1940. The operations of the OPM were severely handicapped by lack of full authority to cope completely with the problem. This lack of necessary authority was in no small part

due to divided public opinion as to America's possible involvement in the European way. After the attack on Pearl Harbor, however, the OPM was rapidly succeeded by the War Production Board which was vested with the necessary powers for decisive action. Drastic and effective conservation steps were then promptly placed in effect.

Briefly described, official tin conservation is to the major extent administered by WPB Orders M-81 and M-43. Order M-81, first issued on February 11, 1942, and since quite frequently amended, accomplished or accomplishes savings of tin in the following general manner:

1. By elimination from tin plate or steel containers of all but essential foods and commodities. Likewise, essential foods which may be packaged in containers other than metal are excluded from metal cans.
2. By specification of the extent to which certain foods or necessary commodities may be packaged in tin plate or steel containers.
3. By elimination of all can sizes below the No. 2 size except for a few specifically exempted products.
4. By a reduction in the tin coating weight applied to hot-dipped tin plate from 1.50# per base box to 1.25# (pot yields).
5. By mandatory use of the conservation or substitute plates for tin plate where experimental evidence indicates the practicability of the use of such plates.

The above provisions of Order M-81 which have, in general, been constantly tightened with each revision of the Order, serve not only to save tin but also to conserve steel, the supply of which has been critical even before war was declared. The M-43 series of orders has regulated the amounts of tin which may be utilized in tin-lead solder in its myriad applications, can manufacture included. Under this order, the present permissible amount of tin in solder has been reduced from its pre-war value of 40 or even 50 per cent, to 20 per cent. It is therefore evident that current tin conservation measures are the most positive and direct which could be taken to conserve the national stockpile of tin so carefully built up by increased tin imports prior to Pearl Harbor. It is also evident that the conservation plates play a major part in the program.

The Conservation Plates

The scope of this discussion will permit consideration from the can maker's standpoint of only one important phase of the tin conservation program, namely, the performance with respect to internal corrosion of cans made from the conservation plates and the extension of the use of cans made wholly or in part from

such plates to food products for which they had never before been employed. There are two conservation plates now specified for use under Order M-81. The first of these is electrolytic tin plate which in its manufacture requires only one-third as much tin as the hot-dipped tin plate widely used prior to the war. The second is enameled, bonderized steel, which bears no tin coating whatsoever.

Genesis of The Conservation Plates

In peacetime, can manufacturers were accustomed to supply two major types or classes of cans. The so-called "packers" or "sanitary" type is exemplified by the well-known fruit or vegetable can; broadly speaking, packers can products are those foods which require a heat sterilizing process to effect preservation. Normally, some 40 odd sizes of packers' cans were available on the market. On the other hand, the general line type of can comprised many hundreds of can sizes and shapes which were utilized for both foods and non-foods, such as dried milk, candies, olive oil, motor oil, paint, tobacco, etc. The manufacture of practically all general line cans was eliminated by the original Order M-81 issued early in 1942.

Referring to the conservation plates, electrolytic tin plate represents a development made by the can manufacturing and allied industries long before the war, primarily for an economic reason. This was to provide a cheaper can for general line products by reduction in the relatively expensive tin coating on the steel base. Electrolytic plate originally was developed for application to the general line commodities, foods or non-foods, which possessed little or no corrosive properties. In contrast, the second conservation plate, enameled bonderized steel, was developed during the year before war was declared in a studied or considered attempt to produce a tin-free packaging material suitable for heat-processed or packers' can products.

In the months prior to Pearl Harbor, as the pattern of Japanese aggression became less obscure and the threat to American tin supplies became more evident, the program of investigation on these conservation materials was greatly intensified. Considerable research was devoted not only to the extension of these plates to the heat processed or sterilized canned foods, but also to study of ways and means of improvement of these materials as then manufactured. Fortunately, this work had proceeded sufficiently far by the time of Pearl Harbor that almost immedi-

ate application of the results by official agencies could be made in the tin conservation program.

Hot-Dipped Tin Plate

For a clearer understanding of the problem of internal can corrosion, some brief mention should be made of the type of tin plate widely used prior to the war.

Most persons are already familiar with the nature of hot-dipped tin plate formerly employed in food and other types of cans. Essentially, it consisted of a thin steel sheet from 0.009 to 0.012 inch thick coated with virgin tin. Several types of "base plate" or steel were customarily used depending upon the type of product for which the can was to be employed. These base plates, predominantly of the cold-reduced types, differed from each other in their content of certain metallic and non-metallic elements. There were also differences in the "temper" or stiffness of the plates. The chemical and physical properties of these plates were likewise controlled by chemical and physical specifications which represent the result of considerable research work and with which the manufacturing tin plate mill had to comply.

Tinning was accomplished by passing the cleaned steel sheets through a bath of molten tin, this operation being so controlled that 1.5# of tin per base box of plate was required for its manufacture. The "base box" is a unit of British origin and represents a total sheet area (on both sides) of 62,720 sq. inches; about 2.6 base boxes of plate are required to manufacture 1,000 No. 2 cans. While 1.5# of tin were needed to make one base box of plate, the actual coating weight on the plate averaged about 1.36# of tin per base box. This type of plate was known as "coke weight" plate and in peacetime was that most widely employed in can manufacture.

Research during the past 15 years has established reasonably well the factors affecting the inside corrosion of tin cans. This chemical reaction is known to be influenced by a variety of factors which have been well discussed by Lueck and Blair (5), Kohman and Sanborn (6), and Hartwell (7). In brief, within the sealed container, tin exhibits a peculiarly protective electrochemical relationship to the iron in the steel base plate which can be upset adversely by a variety of factors. Important among these factors are the continuity and weight of tin coating. While the control of inside can corrosion had been well established for

coke weight tin plate, extension to these products of the conservation plates bearing low tin coating weights or no tin coatings whatsoever, brought grievous problems. Important among these was the problem of conferring corrosion resistance on the conservation plates.

The Manufacture of Electrolytic Tin Plate

As the name implies, electrolytic tin plate is produced by electro-deposition of a tin coating on steel. The same types of steel are used as in the manufacture of hot-dipped tin plate. Tin coatings applied in this fashion show great uniformity and by proper regulation of the process coating weights as low as 0.1# per base box may be produced. This process stands in contrast to the orthodox hot-dipping process for tin-coating steel, since coating weights below 1.2# per base box (pot yield) are difficult to obtain by hot-dipping, and there is usually lack of uniformity in the tin coating on hot-dipped sheets due to the flow of the molten tin. Electrolytic tin plate bearing 0.5# of tin per base box is being currently used in the tin conservation program, since at the time of Pearl Harbor more extensive information was available on the performance of cans made with that coating weight. Current work, however, has established the feasibility of using much lower coating weights for certain applications should occasion demand.

There are at present two general types of electrolytic tin plate, namely, that plated in acid or in alkaline electrolytic baths. Each type is produced in several finishes. The "matte" finish is that of the plate as it leaves the electrolyte and it has a dull whitish appearance quite unlike the sheen of hot-dipped tin plate. The "brushed" finish is produced by brushing the plate with nickel-silver brushes; such plate is characterized by a bright satin-like finish. The latest type, the flow-brightened, fused, or melted finish is produced by melting the tin coating by hot oil, hot air, induction heating, or by resistance heating of the steel. This melting causes the formation of some tin-iron alloy. Melted electrolytic plate is practically identical in appearance with hot-dipped tin plate; in fact, it is well-nigh indistinguishable from hot-dipped coke plate on casual inspection. This type of plate is currently favored by can makers because of its appearance, improved corrosion resistance and superior soldering characteristics. For a fuller description of the development of electrolytic plate, first begun in 1937, and all the problems in-

cident to its use, reference should be made to the recent excellent review of Brighton (2).

Improving the Corrosion Resistance of Electrolytic Plate

It was obvious that the first means of improving the corrosion resistance of electrolytic plate should be through the application of inside enamels or coatings. A great deal of work has already been done along these lines and, briefly summarized, it has been found that surprisingly good inside corrosion resistance can be conferred on electrolytic plate through the application of such protective coatings.

In determining the corrosion resistance of either plain or enameled plates to be used in cans, the most reliable procedure has proven to be the actual performance of the containers made of the plate under test when packed with foods of known corrosive properties. In this testing technique, the plate in question is made into cans; for close control, the ends and bodies of any one can are made from the same sheet of plate. The cans are then packed with various products and the rate of corrosion of the cans followed during storage at ordinary and elevated temperatures. When severe, inside corrosion may be judged by the appearance of "flippers" or "swells" due to the pressure of hydrogen gas formed by reaction of the food with metal or metals of the can. In extreme cases, the progress of corrosion may also be evidenced by actual perforation of the container from the inside.

However, the most useful index of internal can corrosion is the change in "flip vacuum" readings during storage of the cans, particularly during the early days of storage or when the rate of corrosion by the product involved is slow. The flip vacuum device is an instrument for measuring the external vacuum which must be applied to the ends of the can to overcome the internal vacuum and cause the can end to flip out from its normal concave position. As internal corrosion proceeds during storage of the can, the initial can vacuum is slowly dissipated by hydrogen formed through corrosion of the can; consequently, as corrosion progresses lower external vacuums are required to flip out the can end. The rate of flip vacuum loss, as determined by the flip tester, therefore, gives an added picture of the progress of inside can corrosion. Further, flip vacuums may be run repeatedly on the same can over a long storage time without destroying the container.

In Table 3 are shown data from a controlled comparison of the corrosion resistances of plain and inside enameled electrolytic plate cans in which the above testing techniques were used. As controls, enameled or plain cans made from 1.25# hot-dipped tin plate—the types of can used commercially for these foods—were included. All four foods listed are of the relatively non-corrosive class.

TABLE 3. COMPARATIVE CORROSION RESISTANCES OF PLAIN AND ENAMELED ELECTROLYTIC PLATE NO. 2 CANS (AFTER STEWART AND PILCHER)

Product	Can Construction				Storage Time		Results of Storage			
	Ends		Bodies				at 100°F.		at 70°F.	
	Type Plate	Enamel	Type Plate	Enamel	at 100°F.	at 70°F.	Ave. Flip Vacuum Loss	Failures	Ave. Flip Vacuum Loss	Failures
					Days	*Days*	*In.*	*Cans/M.*	*In.*	*Cans/M.*
Peas	1.25*	+	1.25	+	262	269	0.4	0	0.0	0
	0.5**	+	0.5	+	262	269	0.1	0	0.0	0
	0.5	−	0.5	−	262	269	8.2	0	0.2	0
Soup, Chicken Noodle	1.25	−	1.25	−	172	169	0.1	0	0.0	0
	0.5	+	0.5	+	172	169	0.2	0	0.0	0
	0.5	−	0.5	−	172	169	7.4	0	0.2	0
Tuna Fish	1.25	−	1.25	−	142	90	1.7	0	1.7	0
	0.5	+	0.5	+	142	90	1.0	0	1.1	0
	0.5	−	0.5	−	142	90	—	1,000	2.4	0
Sausage in Casings	1.25	−	1.25	−	199	181	2.5	0	1.6	0
	0.5	+	0.5	+	199	181	2.0	0	0.9	0
	0.5	−	0.5	−	199	181	6.7	0	1.6	0

* Hot Dipped Tin Plate.
** Electrolytic Tin Plate.

As will be noted, in the case of tuna fish complete failure of the plain electrolytic plate cans has occurred after 142 days' storage at 100°F. although no failures were apparent in the lots stored at 70°F. This difference in performance of identical cans illustrates the well-known effect of temperature on chemical reactions; in this instance, those reactions causing corrosion. In contrast to the performance of the plain electrolytic plate cans, the inside enameled electrolytic plate cans of tuna fish showed a corrosion resistance entirely comparable to that of the plain hot-dipped tin plate controls.

Inspection of the data will also reveal that in the case of the

other three foods, as judged by the flip vacuum losses, the inside corrosion resistances of the enameled electrolytic plate cans are comparable to those of the hot-dipped tin plate control cans. The flip vacuum records at 100°F. again indicate that plain electrolytic plate cans are commercially unfeasible, even for non-corrosive foods such as those listed. As a result of hundreds of tests of this character, it has been established that inside enameled electrolytic plate cans may serve as satisfactory packages for a large number of non-acid foods formerly packaged in hot-dipped tin plate but not heretofore considered capable of being packaged in this conservation plate. Such findings have been incorporated in revisions of Order M-81 as the information became available. This has been done through the medium of a special committee of the Can Manufacturers Institute created to work closely with government agencies on matters relating to tin conservation (2).

Some Recent Findings on Electrolytic Tin Plate

While inside enameling greatly improves the corrosion resistance of electrolytic plate, there are still points vulnerable to corrosion even within a fully inside enameled, electrolytic plate can. In the manufacture of enameled cans, the plate is enameled in the flat and the can ends and bodies punched out or formed from the enameled sheets. In the body-forming operations, the metal is bent, folded and bumped to form the side seam of the can, and this severe working of the metal may crack the enamel along the inside of the side seam and expose the plate. Likewise, when the enameled end is applied to or "doubleseamed" onto the can body, there is fracture of the enamel and exposure of the plate at the region of the end known as the countersink.

As far as the side seam is concerned, this can be protected by inside striping with an enamel after the body is formed. The advantage of this operation is indicated by the data in Table 4 showing the performance of striped and unstriped enameled electrolytic cans and that of 1.25# hot-dipped controls. Unfortunately, however, such cans show localized corrosion at the countersinks on the ends which render their immediate extension to commercial use with mildly acid foods impractical until the corrosion resistance of existing electrolytic plate is further improved.

A second and more promising finding on electrolytic plate recently made is the excellent performance of a can for corrosive

TABLE 4. THE EFFECT OF SIDE SEAM STRIPING ON THE CORROSION RESISTANCE OF INSIDE ENAMELED ELECTROLYTIC PLATE NO. 2 CANS (AFTER STEWART AND PILCHER)

Product	Can Construction					Storage Time		Results of Storage			
	Ends		Bodies					At 100°F.		At 70°F.	
	Type Plate	Enamel	Type Plate	Enamel	S.S. Stripe	At 100°F.	At 70°F.	Ave. Flip Vacuum Loss	Failures	Ave. Flip Vacuum Loss	Failures
						Days	*Days*	*In.*	*Cans/M.*	*In.*	*Cans/M.*
Beets	1.25*	+	1.25	+	−	220	217	3.2	0	0.3	0
	0.5**	+	0.5	+	+	220	217	3.0	0	0.0	0
	0.5	+	0.5	+	−	220	217	13.3	20	0.9	0
Peaches, Clingstone	1.25	−	1.25	−	−	245	200	1.9	0	0.3	0
	0.5	+	0.5	+	+	245	200	3.0	0	0.0	0
	0.5	+	0.5	+	−	245	200	—	1,000	1.1	0
Tomato Juice	1.25	−	1.25	−	−	225	228	0.2	0	0.2	0
	0.5	+	0.5	+	+	225	228	4.2	0	3.3	0
	0.5	+	0.5	+	−	225	228	10.5	0	4.2	0
Loganberries	1.25	+	1.25	+	+	305	310	7.4	0	1.0	0
	0.5	+	0.5	+	+	305	310	5.1	0	1.1	0
	0.5	+	0.5	+	−	305	310	13.9	380	5.3	0

* Hot Dipped Tin Plate.
** Electrolytic Tin Plate.

products made with enameled electrolytic plate ends on plain, hot-dipped 1.25# tin plate bodies. In Table 5, are shown data taken from the recent report by Brighton (2). The products listed possess distinct corrosive properties, yet the corrosion data indicate that this composite can possesses a very good degree of corrosion resistance as compared with the plain 1.25# controls. Lueck and Blair (5) have shown that corrosion of the base plate is inhibited by stannous ion in the corroding medium. The excellent performance of the cans shown in Table 5 is believed due to the sacrificial action of tin on the plain bodies which dissolves to form stannous ion and retard corrosion of the base plate. If the further results of tests now under way confirm these findings, it is possible that such cans will be used commercially next year to replace cans now made throughout with 1.25# hot-dipped tin plate.

These findings have also stimulated research as to the performance of plain 1.25# hot-dipped ends on enameled electrolytic plate bodies. Sacrificial solution of the tin in such cans is,

TABLE 5. CORROSION RESISTANCE OF COMPOSITE NO. 2 CANS
Enameled, Electrolytic Ends on Plain Hot-Dipped 1.25# Tin Plate Bodies
(AFTER BRIGHTON)

Product	End Construction		Storage Time		Results of Storage			
					At 100°F.		At 70°F.	
	Type Plate	Enamel	At 100°F.	At 70°F.	Ave. Flip Vacuum Loss	Failures	Ave. Flip Vacuum Loss	Failures
			Days	*Days*	*In.*	*Cans/M.*	*In.*	*Cans/M.*
Apricots	1.25*	−	345	300	6.2	137	0.4	0
	0.5**	+	345	300	2.7	33	0.3	0
Royal Anne Cherries	1.25	−	312	240	8.4	200	3.9	0
	0.5	+	312	240	4.0	0	3.1	0
Peaches	1.25	−	300	185	4.3	0	0.0	0
	0.5	+	300	185	4.7	60	0.4	0

* Hot Dipped Tin Plate.
** Electrolytic Tin Plate.

of course, equally possible and tin conservation in the combination of 1.25# plain ends-0.5# enameled bodies is about 50% greater than the combination of 0.5# enameled ends-1.25# plain bodies.

Enameled, Bonderized Steel

As has been previously stated, enameled steel also figures prominently in current tin conservation plans. While steel or "black iron" containers or container parts have been manufactured by can makers for years, this new type of enameled steel was made possible by the combined research efforts of the Parker Rust-Proof Company, the Carnegie-Illinois Steel Company, and our Research Department largely during the year before Pearl Harbor. For many years one major objection to ordinary sheet steel, coated or uncoated, was its high susceptibility to atmospheric corrosion. In the plain flat sheet or the uncoated can part, severe rust ultimately would develop; untreated enameled steel also showed underfilm corrosion manifested by fine hair-like masses of rust which formed under the enamel film. Untreated steel also displayed very poor enamel adhesion, as compared to the adhesion of hot-dipped tin plate.

The newly developed "bonderizing" treatment—adapted to its present usage from the automotive industry where it had been used for some years—confers on steel a high degree of rust resistance and, equally important, a high degree of adhesion to

enamels which is unsurpassed even by coke weight tin plate. The bonderizing treatment consists essentially of a treatment of the steel with a solution of zinc dihydrogen phosphate and an oxidizing agent. A fine deposit of mixed crystals of zinc and iron phosphates firmly adheres to the sheets and it is to this deposit that the rust resistance and high degree of enamel-adhesive properties of the sheet are attributed. At present, only can ends made of bonderized steel bearing two enamel coats on the inside and one on the outside are being used in the current

TABLE 6. PERFORMANCE OF ENAMELED STEEL ENDS ON PLAIN HOT-DIPPED TIN PLATE BODIES*
(AFTER STEWART AND PILCHER)

Product	*p*H	Can Construction			Storage Time		Results of Storage			
		Ends		Bodies			At 100°F.		At 70°F.	
		Type Plate	En-amel	Type Plate	At 100°F.	At 70°F.	Ave. Flip Vac-uum Loss	Failures	Ave. Flip Vac-uum Loss	Failures
					Days	*Days*	*In.*	*Cans/M.*	*In.*	*Cans/M.*
Asparagus	5.4–5.6	1.25**	−	1.25	320	263	1.6	0	0.0	0
		B.S.***	+	1.25	320	263	2.8	0	3.0	0
Green Beans	5.2–5.7	1.25	−	1.25	225	246	5.0	0	0.1	0
		B.S.	+	1.25	225	246	4.9	0	1.1	0
Peaches	3.6–4.1	1.25	−	1.25	245	200	1.4	0	0.2	0
		B.S.	+	1.50	245	200	0.8	0	0.3	0
Spinach	5.1–5.9	1.25	−	1.25	145	196	3.6	0	2.1	0
		B.S.	+	1.25	145	196	1.5	0	0.9	0
Tomato Juice	4.0–4.4	1.25	−	1.25	225	228	0.2	0	0.2	0
		B.S.	+	1.50	225	228	1.9	0	3.3	0

* Number 2 (307×409).
** Hot Dipped Tin Plate.
*** Bonderized and Enameled Steel.

conservation program. The problem of fabricating and soldering enameled steel bodies on a commercial basis and at usual operating speeds is still a major problem for the research and development departments of the industry. Considerable quantities of highly strategic metals would be required to modify and equip existing can manufacturing lines to do a satisfactory job on bonderized steel bodies even at slower speeds. Also, as later indicated, an equally effective and more practical means of tin conservation has been disclosed.

The results of early tests with enameled steel containers suggested that the pH of the food product might be the conditioning factor as far as the use of bonderized can ends was concerned. In general, it appeared that only food products with pH values of 5.5 or higher should be packaged in cans bearing enameled steel ends. However, results of additional experimental packs are now available which, although subject to further check through experiments now under way, show considerable promise as far as extending the use of enameled, bonderized steel is concerned.

The results of one of these experiments are shown in Table 6. The data in the table indicate that with products such as spinach, green beans, and possibly asparagus, all of which are in the pH range of 5.0 to 5.5, the use of enameled steel ends on electrolytic bodies might be possible if further tin conservation is required. The performance of the cans packed with peaches

and tomatoes, both of which have a pH well below 5.0, is much better than expected, but will have to be thoroughly checked by other experimental packs before enameled steel ends could be considered for these products.

The Stages of Tin Conservation

Having considered the general plan of tin conservation and several of the conservation materials which are featured in that plan, two questions might well be asked, namely, just where we stand with respect to the use of these materials and how much tin has been saved during the current year by the sum total of all conservation measures which have been applied.

With respect to current use of the conservation plates, reference might first be made to the detailed plan for tin conservation officially evolved in December, 1941, and described by Lueck (1). This original plan recognized four distinct phases or stages in tin conservation through which the program would progress

as production of the conservation materials increased and technological difficulties incident to their use were overcome. The containers for three of the four stages discussed by Lueck are shown as Figure 1.

As will be noted from this figure, Stage I containers were made entirely from 1.50# and 1.25# hot-dipped plate (pot yields) and bore tin-lead solder; the total amounts of tin required per 1,000 cans were 4.07 and 3.44 pounds for the 1.50# and 1.25# cans, respectively. In stage II, cans made with 1.25# hot dipped tin plate bodies and bearing either electrolytic plate or enameled steel ends were prescribed, and silver-lead solder used in can manufacture. Thousands of these containers were used during the 1942 canning season. As will be noted, the amounts of tin required to make 1,000 cans of these types have fallen to 2.48 and 2.0 pounds respectively. As we proceed to Stage III, the conservation stage in which we are now operating, the savings in tin are even more pronounced. In this stage, silver-lead solder is again used on cans made entirely of electrolytic plate, or bearing enameled steel ends on electrolytic plate bodies. The overall saving in tin between the 1.5# hot-dipped can of Stage I bearing tin-lead solder and the Stage III container made with silver-lead solder and composed of enameled steel ends on electrolytic plate bodies is in excess of 3 pounds of the metal per 1,000 cans.

The fourth phase or Stage IV of tin conservation first described by Lueck was the use of a container made wholly of bonderized steel. However, experiments made since then have shown that to use this type of plate in can bodies, the side seams must be soldered with tin-lead solder. In addition, extensive alterations in existing can-making equipment would be required and such alterations would necessitate the use of a considerable tonnage of highly critical materials, primarily steel and other metals. Consequently, in Stage IV, the "all out" stage, if necessary it is now proposed to use electrolytic plate of 0.25# tin coating for the can bodies which will permit them to be soldered with silver-lead solder. This switch in plans for the composition of can bodies will not require the use of any more tin per 1,000 cans than the use of bonderized steel bodies soldered with tin-lead solder.

As to the total savings in tin effected this year, this information is a closely kept secret and is properly one only for official discussion. In the same category, one may include the extent of the national tin stockpile, the amount of tin imported and the

amount produced in America during 1943. However, as stated, we are now well into Phase III of the conservation program. Despite the unprecedented heavy demands for tin plate packaged foods for Lend-Lease purposes and for the supply of food, ration, blood plasma and other cans for our Armed forces, thanks to the conservation plates and solders, the estimated total 1943 tin consumption is far below the 1940 consumption of 37,964 long tons of tin for tin plate manufacture used primarily for civilian purposes. The extent of savings, like the extents of tin imports and production for this year, are known only to those in high official circles.

As for the future outlook for tin, this again is best a subject for official discussion. It does, however, provide small comfort to the Axis to state the fact, already disclosed, that Australia, Nigeria and the Belgian Congo are now producing tin for Allied use. Also, an American smelter operating on Bolivian concentrates with an annual capacity in excess of 50,000 long tons of tin has long been in operation. Above all, however, it is comforting to know that tin conservation rests in competent official hands. In cooperation with those agencies charged with tin conservation, the can manufacturing industry has dedicated all the ingenuity and energy of its technical units to insure that our national reserves of tin, the "Cinderella metal," will be adequate for military and civilian needs until the victory is won.

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All knowledge is lost which ends in the knowing.—Ruskin.

THE TEACHER'S ROLE IN A DEMOCRACY

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Professor Anton J. Carlson, of the University of Chicago, gives this as his ideal of a democratic society, "To my way of thinking," he said, "a truly democratic society is that social, economic and political order which favors or permits the maximum freedom and opportunity for the efforts and achievements of the individual, consistent with the common welfare, and gives the individual full or equal share and responsibility in establishing, balancing and sustaining that freedom and responsibility. Again, to my way of thinking, this does not mean equal responsibility from each citizen, for we are not born with equal capacities, mental, moral or physical. If there was now, or could ever be devised a way to assess individual capacity, I think we would be on the road to a closer approximation to social and economic justice for all than is the case in any extant democratic society or democratic way of life of which I have ken."

He goes on to say, "Failure to realize democracy, despite the many trials that have been made, is due to the eternal cussedness, the dishonesty, the greed, the vanity, and the laziness of man. But although this goal seems as far away as the proverbial rainbow, I would rather chase this rainbow than stay contented in the jungle."

Hu Shih, former Chinese ambassador to Washington, in his book, *The Chinese Renaissance*,[1] reviews the development of Chinese thinking of recent years, with a view to adopting Western ideas to China's needs. He tells how science and technology were first advanced as the reason for our progress; how they reasoned further that the democratic ideal contributed to this development. Then the evils of capitalism began to be discussed. This was followed by the conclusion that capitalism resulted from following the individualistic ideal of democracy too closely, which led them finally to decide that Russian socialism most nearly answered China's needs, for there science and technology are flourishing without the individualism so prominent in other parts of Western civilization.

He sums up thus, "Are we not tempted or even justified in viewing the socialistic and communistic movements, not as

[1] Copyright 1934 by the University of Chicago Press, Chicago, Illinois.

tendencies alien and extraneous to western civilization, but as an integral part of it, as the logical consequence in the fulfillment of its democratic ideal, and as merely supplementary to the earlier and more individualistic ideas of democracy?"

Hu Shih's observations are very revealing, but he does not go far enough. In the first place, while the democratic trend underwent a long period of gestation in Europe, democracy had its real birth here in America. What degree of democracy other countries now enjoy has been largely the result of using our plan as a foundation. In those countries where the plan, but not the spirit was adopted, dictatorship has been the inevitable result. Even in our own country we still have the plan in the form of the constitution, but the spirit has become "sicklied o'er by the pale cast" of indifference. In the second place, Russia's development in science and technology has received considerable impetus by studying the developments made in this country. Many of their young men have been sent here to study our methods, and many Americans have been imported there to build their dams, power plants and factories. Now that these improvements have been installed, the very spirit of individualism and encouragement of initiative which created these tools is now discounted. Is the average American ready to frown on these virtues by which man climbs the ladder,—

> "But when he once attains the upmost round,
> He then unto the ladder turns his back,
> Looks in the clouds, scorning the base degrees
> By which he did ascend."

—as William Shakespeare puts it in his Julius Caesar? Are we willing to admit defeat because we haven't the courage to make democracy work, or are we going to drift into an easy socialism where the individual is stifled to the extent that one man, or a small group, is necessary to decide the policies for the whole country?

That Hu Shih, in spite of the line of reasoning he follows, failed to reckon with this smoldering spirit is evidenced by the fact that one can hardly pick up a paper today without finding several articles among the editorials, the columnist's comments or the contributor's writings something to the effect that individual initiative has been trampled. That is why I believe in America's hope for the future. To me these are indications that some Americans are still virile and courageous, that they still

have the spirit which has made this country strong from its inception, that Hu Shih was looking at the surface only, turning a deaf ear to the rumblings of individuals awakening from their indifference.

This trend toward socialization is a logical result of scientific development and industrialization. These have led toward mass production, mass production toward amalgamation and centralization, and centralization to dictatorship. At first this power was vested in the capitalists. Then labor began fighting for its rights which was also logical in a democratic society. Now labor groups seem to be dominated by other dictators with a lust for power as great as the moneyed interests had. When they become equally powerful, the result is either a stalemate or an appeal to a still higher authority. If that higher authority exercises his power, he in turn becomes the big dictator. With each step toward centralization, the individual has become a less and less important pawn.

Through all this turmoil there have been some concerns which have avoided labor trouble and in which labor unions would be unwelcome. Back of every amicable relationship, from the home to society in general, as nearly equal consideration is given the individual and the group as is humanly possible. Self-interest and generosity, loving and being loved, respecting and being respected, are balanced as nearly as possible. Few fixed laws are followed, but each situation is a new problem to be solved. Discipline is not a major problem, because each is given more freedom to be his own disciplinarian. Formulas are few, rather, understanding is the keynote. If society is to progress at all in the right direction, it can be only through the gradual discarding of regulations as we develop faith in each other; through exercising less compulsion and encouraging more volition; through more shaking of hands and less shaking of fists; through giving the individual more and more power as he displays his ability to use that power to his own best interests and those of his neighbor.

Inequalities will always exist, but with schools, as with any human relationship, equality can never be accomplished by more amalgamation and centralization. Any progress toward equalization can be realized only by considering individual needs. As long as we take the attitude that others are getting more consideration by banding together in order to bring more pressure to bear, we will always be at odds.

Those who have favored Federal support of the schools have logically extended a principle which has always maintained in our public schools—that they are the *public* property. The concept of the "public" has merely been extended. That pure logic can lead us into still greater problems than already exist is made clear if we take the next step and make equalization of educational opportunity an international instead of merely a national problem. If an individual took the attitude that his children should not have an opportunity for higher education until he had made it possible for all the neighbors' children to share equally with his own, the pure logic of this principle ends in futility. It is understandable that the public has been aroused by this move of the teachers because the public believes, and rightly so, that the schools are the property of groups of citizens and not of the teachers. If the entire public were convinced that equalization of educational opportunity were necessary or desirable, such moves by teachers would never need to be made. All would then be working toward that end.

A man, like a community, is entitled only to the possessions and esteem which he has earned through his own efforts. This esteem granted by society is due in part to his inherited capacities and partly to the degree to which he has developed his abilities. In like manner, if we could early determine accurately a person's potentialities, society would owe each individual that degree of opportunity which this test indicated, simply because he could contribute to society in that degree. That is the principle which guides the granting of scholarships. It is indeed fortunate that scholarship funds are still largely the result of voluntary contributions, although some agitation is now being aroused to secure them by taxation.

In her book, *The Moral Basis of Individualism*,[2] Miss Ayn Rand says, "Some humanitarians demand a collective state because of their pity for the incompetent or Passive Man. For his sake they wish to harness the Active. But the Active Man cannot function in harness. And once he is destroyed, the destruction of the Passive Man follows automatically. So if pity is the humanitarian's first consideration, then in the name of pity, if nothing else, they would leave the Active Man free to function, in order to help the Passive. There is no other way to help him in the long run."

[2] *The Reader's Digest*, January, 1944. From a forthcoming book to be published by the Bobbs-Merrill Co., 468 Fourth Ave., New York City.

If this automatic formula for distributing the money to the schools of the nation is really just, it will consider many things besides average daily attendance. It will take into account, for instance, the varying cost of building, equipping and maintaining schools in various parts of the country, particularly where the climate differs. There will be consideration of the cost of transporting pupils to school in widely scattered mountainous districts as compared with that in more compact level country. The needs of more costly equipment in communities where highly technical training is desirable will be a factor. They will not forget the greater cost of living for teachers in large cities as compared with those living in rural communities. Consideration will be given to the amount of formal training of the individual teacher, as well as his professional growth since entering the educational field. There will be a measuring stick designed to determine how much help each community deserves on the basis of what it has already done in proportion to its ability to support schools. Through no fault of the school, an epidemic in a certain locality would influence the average daily attendance, thus cutting down on its apportionment. Some of these problems deserve more consideration locally.

How, then, can broadening the support possibly accomplish *more* justice? If such a formula could be devised on a national scale, would it not be so cumbersome and need so much revision as changes occur, that in the end we would decide it would have been much better to have left it as nearly a local problem as possible? The program of centralization is the same in this case as elsewhere—the amount of red tape and regulation necessarily increases as we move farther from the individual. One cannot fail to see the logic of those who favor making just one more step in the direction of centralization, but the question is, "Shall we continue in the direction Hu Shih sees we are heading, or shall be begin somewhere to call a halt?" Shall we continue to serve the "common good" at the expense of individual freedom, or shall we decide that more emphasis on freedom of the individual best serves the needs of all?

Our main task as teachers, as I see it, is not that of making laws for the reformation of society, any more than it is the duty of a policeman to do so. We are public servants entrusted with the far more difficult task of training individuals for life in a democratic society. What goes on in the next classroom, the next county or the next state should not concern me nearly so

much as what happens in my own classroom, and more particularly my relationship with each individual pupil under my guidance.

Christ, the greatest teacher of all, wrestled with this same problem. He realized that he might assume temporal power and enforce his ideas en masse. But he chose the only sure, but slower method, of influencing the individuals with whom he came in contact. He counseled, advised and admonished, but the final decision was left with them. To the rich man he said, "Go, sell all thy goods and give to the poor." The man's right to his possessions was not questioned. Whether or not the poor profited from such advice was important only in proportion as the giving was a willing and voluntary gesture. He did not say to his followers, "adjust or die," "conform or be purged." Rather it was, "Judge not, that ye be not judged," live and let live. They said to him, however, "Desist or we'll bear witness against you." Because he did not, they crucified him. But did he die? Is he not still living in the hearts of men everywhere who try to live his democratic way of life? That is why non-Christian countries find it so difficult to realize much semblance of democracy. That is why the Christian church and people fare so badly when collectivism and subsequent dictatorship come in—the principles of the two cannot exist in amity side by side.

While, then, we may see these inequalities and do all we can about them on a voluntary basis, let's mot make the fatal mistake all forms of totalitarianism make—believing reform can be accomplished by force. Impatience with the progress of mankind may do credit to a man's sympathies, but it can never condone his folly for making the brave, but futile attempt, to build the top stories before the proper foundation has been laid. Our task, then, is that of advocating and practicing the democratic way of life to the end that future citizens will be more loyal employees, more considerate employers, more just statesmen and better qualified parents and teachers. The degree of social justice can only rise or fall in direct proportion to the kind of justice practiced by the individual members of society. This is chasing Professor Carlson's rainbow of democratic idealism but, to paraphrase another quotation from Shakespeare's *Julius Caesar*,—

The fault, dear fellow-teachers, is not with the rainbow,
But within ourselves, that we do not chase it more diligently.

PROBLEMS FACING GENERAL SCIENCE TEACHERS*

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The function of general science remains tody what it always has been—that of giving a broad background of science experiences. The war is not yet close enough to the junior high school to justify a specialized war-time program. There remains to each pupil at least three years of schooling during which period he can be given training recommended by military authorities.

This does not mean that we may sterilize our teaching of all mention of war. To do so would be ridiculous. Much that we teach can give meaning to what pupils hear about war; what the pupils hear about war can give meaning to what we teach. We should take advantage of the interaction.

The problems we face in general science teaching are essentially those we would have faced in normal times. The war has sharpened our perspective, it has made us conscious of weaknesses we did not suspect, and it has increased the tempo of our lives, thus hastening inevitable changes

The problems we face fall in two general categories. Our way of life is constantly changing; we must adjust our general science curriculum accordingly. Our teaching procedures are far from perfect; we must strive to improve our teaching.

To be specific, the development of airplanes has brought about a series of problems. Although a great deal has been written about airmindedness, almost to the point of boredom, survey of recent texts and talks with teachers reveals that much missionary work remains. We must, first of all, change our way of thinking. The airplane is no longer a plaything for reckless people; it is a definite part of our civilization with rank equal to that of the railroad and automobile. Until general science teachers have made that change in their thinking, they will not do justice to the subject.

We need also to know just how far we can go in the study of the airplane. Teachers of science have a tendency to push certain subjects too far, pursuing their own interests and perhaps those of a few pupils, with disregard for the ability of others to follow.

* Digest of a paper presented at the winter meetings of the New York State Science Teachers Association at Albany, December 29, 1943.

Teachers will do well to experiment in the teaching of aviation. It is to be hoped that they will publish their findings so that others might be benefited.

A safe rule for teaching a new subject is to go no farther than our ability to provide first-hand experiences. If a real plane is available, or if pupils can construct a large model with movable controls, it is safe to teach about the action of the control surfaces. But if the action of the control surfaces is taught *without* giving first-hand experiences, only those pupils with the proper background will be benefited. Do not be misled by the enthusiasm of these few or even by the correct answers of the others; the chances are that the majority of the class, particularly the girls, will not be developing proper concepts.

This matter of forgetting to develop a suitable background of first-hand experiences applies to another topic already well established in the curriculum—the automobile engine. Probably no subject is more poorly taught. Teachers depend upon texts, diagrams and charts, upon sectional models and upon animated drawings. None of these will serve unless the pupils also have access to a real engine that can be taken apart. It is true that engines are difficult to store in a science laboratory but there is usually some place in the school where one can be kept. Without a real engine, teachers might better spend the time on some other subject for which first-hand experiences are possible.

The new importance of the airplane has brought into prominence certain concomitant subjects. Map reading has rarely been touched upon in general science, but the reading of maps is something everyone should master. Time and direction are two other phases closely allied to aviation because of their importance in navigation. Time, in particular, is sadly treated. The idea of standard time is often mentioned but the whole matter of the true solar day and the mean solar day are ignored. Some teachers do not even realize that time as given by our clocks is purely arbitrary.

The subject of meteorology is much abused. Texts are still including the theory of the origin of low pressure areas as given previous to 1895. No general science textbook writers, so far as the writer has observed, have kept up to date on weather study. This made no serious difference so long as we were earth bound, but now that life itself depends upon an understanding of weather, we must take care not to introduce wrong concepts.

Again, we also need to know just how far we can go. The

writer has been experimenting with seventh and eighth grades to discover the placement of certain weather topics. Pupils were able to recognize the passage of warm and cold fronts when these were not too masked by other phenomena, but they little understood the relation of fronts to the air masses. They were able to understand the simpler phases of convection and condensation, but an interrelationship of these two phenomena, namely the moist adiabatic lapse rate, was completely beyond them. We must develop topics for which firsthand experiences are possible and organize these so that the pupils will have a sound experience background for advanced study of weather.

Military authorities have been horrified at the lack of training in mechanics, and with reason. Review of texts and courses of study reveals that it is usually considered sufficient to have pupils classify devices as one of the six, or five, or four, or what-have-you, simple machines. Classification serves little purpose until pupils are ready for mathematical treatment. What is more important in the junior high school is to give pupils experiences with the tools themselves. With hammers, nails and boards, let them discover the properties of hammers, no simple subject but one of vast importance and applicable to all sorts of pounding tools. Let them work with knives; knives are usually listed as wedges but only a small part of their usefulness can be attributed to wedge action. Several days spent with the tools of kitchen, woodshop and barn will give pupils a most valuable background in mechanics.

Chemistry, particularly organic chemistry, is bringing about great changes in our lives and general science should begin a background in this field. But it should not be the formalized chemistry now suggested. Pupils need experiences with the simple chemicals of the household such as drain-cleaners, baking powder, soap. From these experiences they will gain the fundamental concepts of chemistry.

Biological aspects have been receiving less emphasis in the general science program. Few actually favor this trend but the causes are understandable. The biological material in the texts and the courses of study has become increasingly formal until now it represents little but a condensed general biology course. It fails to stimulate either pupils or teachers.

A wise procedure will be to go back to the tested practices of nature study. The underlying motif of nature study is to study things, not ideas; in other words, study bears and woodchucks

and skunks rather than such abstract ideas as hibernation. Pupils are more interested in this approach because they have had experiences and can make contributions. There is also less danger of falling into the standard pitfall of general science—unwarranted generalizations.

Problems thus far discussed are those which will probably demand an increased share of the general science time allotment if they are to be solved with any degree of satisfaction. This raises another issue. The program is already overloaded to the point where the treatment of most subjects is undesirably superficial. Some topics must receive less emphasis or else be eliminated altogether.

Were we to follow the philosophy that we confine ourselves to those topics for which first-hand experiences are possible, much would be automatically eliminated. Radio would be left out of the program, at least insofar as the construction and operation of radio is concerned, because we cannot hope to give most junior high school pupils an understanding of radio.

Many phases of astronomy, excepting the study of constellations, time, direction and location, would be left out of the program, although some might wish to see a very brief treatment of the solar system retained. But all the work on the composition of the stars, the study of galaxies, and nebulae would find no place in the program. Little harm would be done by this deletion.

In geology more time would be spent on identification and uses of rocks and minerals, and on geologic processes, at the expense of the study of dinosaurs and the theories of the origin of the world and of the evolution of life. Once again, little harm could result. It is pleasant to have a background in such cultural phases of science but there are other phases more valuable. We can leave the acquisition of cultural topics to later years or to independent study.

The writer has become increasingly skeptical of the wisdom of studying in general science the molecules, the atoms, the electrons and the other "particles" of physics. Explanations in terms of these theoretical bodies have been pushed down into the elementary curriculum until we find them on fourth and fifth grade levels.

Every topic in general science can be studied effectively without reference to the molecular and electron theories. It is as easy for a pupil to think of a steam engine cylinder as filled with steam as with the little black and white balls pictured in educa-

tional films. To introduce the theories adds an unnecessary complexity discouraging to many pupils.

Senior high school teachers find of little value the general science ground work in molecular and electron theories. In fact, so arbitrarily are the theories introduced that pupils never realize that they are no more than theories. Senior high school teachers are denied the opportunity for developing a truly scientific attitude toward theories.

We should realize that the theories of the "particles" are today exceedingly complex, involving radical changes in our concepts of space and mass. The theories are tools for the hands of research workers: they are too tenuous and too delicate for the hands of pupils who are no more than children.

It can be seen that our problems actually resolve themselves into one major problem,—that of swinging teaching practices back part of the way to where they were some twenty-five years ago. At that time, teaching in the grades was governed by the nature study philosophy,—study things, not ideas. Rebellion against a lack of sequence and a tendency toward sentimentalism, both of which marked so much nature study teaching, caused a swing toward a more formal, highly organized curriculum. To a point, this was a healthy move, but the pendulum swung too far, and we find science programs so filled with generalizations and abstractions that they resemble Sunday newspaper supplements more than science. War has revealed the folly.

If now we will return to the philosophy of studying things, not ideas, which was the heart of the nature study program, and retain the sequence and organization shown in later programs, we shall have solved many problems of subject matter selection and treatment. Perhaps we can raise a generation of children who are eager to learn science, in place of the many apathetic and antagonistic pupils we turn out today.

After schooltime ends we must not throw our youth uncared for and unsupervised on the labor market, with its blind-alley occupations which start so fair and often end so foul. . . .

We must make plans for part-time release from industry so that our young people may have the chance to carry on their general education and also to obtain specialized education which will fit them better for their work.

WINSTON CHURCHILL

THE EDUCATIONAL USE OF SOAP BUBBLES*

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The purpose of this lecture demonstration is to suggest various soap film experiments that can be made to demonstrate or illustrate educational truths. We shall consider, also, the techniques involved for such demonstrations.

We shall at once limit our discussion to some of the class room uses of bubbles. Thus we shall not here consider the interesting study of surface tension, cohesion, and soap film phenomena. It seems well to state, however, that there is a very fine little book by C. V. Boys entitled, *Soap-Bubbles—Their Colours and The Forces Which Mould Them.* This book is printed in England and is sold by the Macmillan Company of New York.

The major problem of making soap film demonstrations is that of a suitable solution. It is very easy to prepare a poor solution; any soap in water will probably give unsatisfactory results. A good solution can be made by dissolving 75 grams of sodium oleate in one liter or quart of hot distilled water and then adding one half liter or pint of pure glycerine. Possibly a better, and more conveniently prepared, solution is made by using a now available soap bubble concentrate. By mixing one part of the concentrate with two parts distilled water (this may be mixed in a bottle), a solution is made that is at once ready to use or may be kept for reuse.

Following are some demonstrations which show the use of soap film. Most of these require simple equipment and little skill. Many of these demonstrations are commonly made by Science teachers, while others may be new.

1. Surface tension and cohesion are demonstrated by the contracting force of a soap film which pulls an aluminum wire up the sides of a six-inch metal U-shaped frame.

2. By dipping a wire ring (7 inch) in soap solution, a film easily forms on the ring. Now a small aluminum ring is made to hang from the film on the large ring. To make the ring more visible, a tiny streamer is attached to a cross wire of the tiny ring. When the streamer is pulled down by the hand, the entire film is distended several inches. When the streamer is released,

* A Lecture Demonstration for the Physics Section of the Central Association of Science and Mathematics Teacher's Convention at the Palmer House, Chicago, November 26, 1943.

the contraction of the film jerks the tiny ring and streamer back up into its natural position, thus doing work against gravity by overcoming resistance through space.

3. An ordinary coat hanger may be reshaped so that the space between the wires is constant of say $1\frac{1}{2}$ inches. This space may be loaded with a film by means of a paint brush. A bubble placed on the film will gravitate as we tip the coat hanger back and forth; but if we should break that part of the film that is below the bubble as it is descending, we shall be delighted to see that the bubble apparently climbs a hill as the film above it contracts.

4. The spherical shape of the bubble is in itself a demonstration of the dominant tendency of soap film to take the shape of minimum area, for it is the sphere that has the minimum surface area for a given volume. However, this truth is easily shown by merely permitting the bubble to exhaust itself through the bubble pipe. If a large bore pipe is used, the exhaust may be so rapid that a burning candle can be extinguished by its blast.

5. When a cubically shaped wire frame, of about 6-inch edges, is loaded with soap solution by rotating it in the solution, an interesting demonstration, with film formations, is produced. It is easy to have film surfaces form from each edge diagonally to the central part of the frame where a small square-like section of about one square inch will be produced. This little section, again, shows the economy of soap formations to take whatever shape is necessary in order to reduce the total surface area to minimum. Now if the frame is again placed in the solution, so that the four edges of one face are under the solution, air will be trapped under the above formations and it will be possible to lift out a bubble that is not blown by mouth but made by manipulation. It will be observed that the bubble is beautifully distorted from the spherical shape as the diagonal formations tend to pull it into the shape of a cube.

6. If the above operations are repeated with a tetrahedron frame, even more beautiful distortions are produced which show the forms of minimum surfaces.

7. When two wire rings of the same size are dipped in the solution together, it is possible to separate them with the film between them forming a catenoid. This lovely formation is another example of a curved surface that does not produce pressure, in contrast to the curvature of the spherical bubble that does produce pressure by its contraction. Practical applications

of the use of soap films over various shaped frames are, according to Mr. Cook in the April, 1938, *Journal of Chemical Education*, found in engineering research on torsional stresses and on the distribution of stresses in beams and structural members. "This is because of a mathematical analogy between the torsion or stress of the member, and that of a membrane (such as a soap film) subjected to an excess of pressure on one side, as by compressed air."

8. Because of greater curvature per unit area, the smaller the bubble the greater the pressure produced by the contracting film. This is demonstrated by connecting a small bubble with a large bubble. The small bubble soon deflates itself into the large one. And this is an application of Pascal's Law; for as the two bubbles do not produce equal pressures, the gas in the bubble of greater pressure immediately transmits itself into the one of lesser pressure.

9. When three equal forces act on each other so that each is the equilibrant of the other two, the forces act at 120 degrees. The joining of separate soap films is a remarkable example of this truth, for soap films always join three together and at 120 degrees.

10. Color produced by the interference and reinforcement of light waves is most easily demonstrated by soap film. A plane film on a vertical frame soon exhibits pretty and wide color bands. Or if a bubble is placed upon a watch glass, its color can easily be observed.

11. The effusion of a gas like hydrogen through a membrane is shown when a bubble is inflated with hydrogen and placed on a watch glass for a few minutes; the bubble becomes smaller. If, however, a bubble blown by exhaled air is placed on a watch glass that is fastened inside of a glass jar and if the jar is then filled with hydrogen and sealed, the bubble will grow larger as hydrogen passes into it.

12. It is possible for a bubble to show the presence of a gas. If a small bubble is placed within a 3-inch vertical ring so that it bulges on one side just a little more than on the other, and if a stopper wet with ammonia water is held near the larger side, the bubble will slip through the ring as if to get away from the odor. The bubble may be moved back and forth several times.

13. It is said that the lung capacity of an adult is approximately one gallon. By blowing just one full breath into a bubble, the volume of the exhaled air may be estimated. A large bore

pipe should be used. A round cardboard having a diameter of a sphere of one gallon capacity is handy to have for comparison.

14. If instead of placing the pipe against the lips, the pipe is held an inch in front of the mouth, and one lung full of air is blown into the pipe, atmospheric air will be pushed in also, and the bubble will be about twice the size of the one that showed lung capacity. A large tube (1-inch) can be used as a pipe. This is a demonstration of Bernoulli's Principle.

15. Relative volumes of spheres can be shown by means of bubbles that are inflated by an automobile tire pump that throws a definite amount of air per stroke. By means of a mirrored meter stick, the diameter of the bubbles can be ascertained; and by counting the strokes of the pump, the relative volumes are known. By putting one stroke of air in one bubble and eight in another, it will be shown that the volume of a sphere varies as the cube of the diameter as the second bubble will have exactly twice the diameter of the first. The relative sizes of bubbles having any volume ratios can be observed.

16. Bubbles are often used to demonstrate the buoyancy of gases. If a very small pipe is used, it is quite easy to drop a bubble on carbon dioxide in a big beaker or jar.

17. The fact that warm air is lighter than cold air can be proved by blowing a hot air bubble. The hot air bubble is produced by merely blowing through a hot tube. The hot air bubble will rise, cruise, and then descend.

18. The lifting ability of hydrogen is always a pleasant thing to show. Because hydrogen is so light, it will tend to pull the bubble off the pipe before it is large enough to release easily; but if exhaled air is introduced into the hydrogen line by means of a T-tube, the bubbles can be blown larger.

19. The soap bubble is the perfect and ideal container to use for showing the explosive properties of gases for there is no danger of flying glass. Not only is it the safest, but it is the most spectacular means of convincing pupils that one part oxygen with two parts hydrogen is explosive and dangerous. The bubble should be blown with oxygen and then finished off with twice as much hydrogen, and then the bubble should be released from the pipe so that there is no chance of igniting the gas in the pipe. The bubble can be fired in mid air, or it can be placed upon a watch glass for firing. A candle on a stick or a birthday candle pushed in a glass tube can be employed as the firing stick. As to how much bigger in diameter the finished bubble should be

compared to its size with just oxygen in it is a nice problem for a pupil to solve.

20. A very interesting and spectacular sound picture can be made by the use of soap film. Sound waves are allowed to pass into a chamber that is closed by a (2-in.) square soap film. The sound agitates the film into nodes and antinodes which gives a definite pattern for pitch, intensity, and rhythm. By means of projection equipment, the reflection of light from the soap membrane may be directed upon a screen.

Many more demonstrations and tricks of educational value can be made with soap bubbles. An assortment of tricks that seem to be of greatest practical value as teaching aids has thus been listed. It is hoped that these demonstrations have again shown that even the most common and least suspected things may help to intrigue one into a study and appreciation of nature's great storehouse of truth and beauty. As Mrs. Browning so beautifully states in her poem, "Aurora Leigh":

> "Earth's crammed with heaven,
> And every common bush afire with God;
> But only he who sees takes off his shoes."

Certainly it is the great privilege and noble task of the science teacher to help pupils to "see."

And for us who teach Science, there is an "Educational use of Soap Bubbles."

THE UNIVERSITY OF CHICAGO WORKSHOP

Special features of the University of Chicago Workshop this summer will be sections on Inter-American Education and Aviation Education. Participants, in addition to receiving help and counsel from consultants especially selected for their competence in these fields, will hear lectures, see films and have access to much new material pertaining to Latin-America and Aviation.

Ralph W. Tyler, Chairman of the Department of Education, is director of the Workshop, which will include sections on Elementary and Secondary Education, and Human Development. Teachers, administrators and librarians who wish help in solving problems in their own classrooms and in adjusting their schools to war and post-war demands will be particularly interested in the offerings in curriculum, guidance, and evaluation.

A limited number of scholarships paying either full or half tuition are available. Further information may be secured by writing to James B. Enochs, Executive Secretary of the Workshop, University of Chicago, Chicago 37, Illinois.

AN EXPERIMENTAL CONSTRUCTION OF THE SINE CURVE

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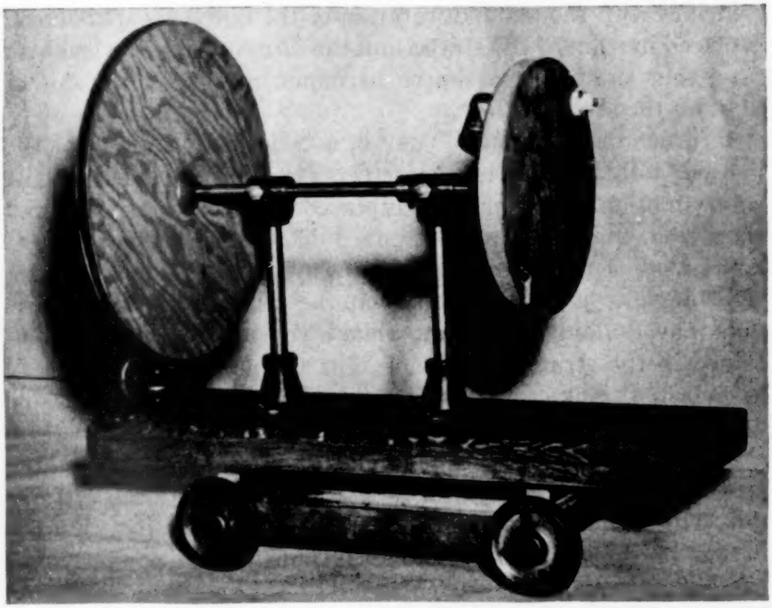
Recognizing the importance of a derivation of the sine curve in a study of vibratory and wave motions, many authors of textbooks on general physics have included a graphic construction of that curve in their discussions. In this construction equidistant points on the circumference of a circle are projected onto a diameter, which serves as the ordinate of a cartesian



system. Equal intervals of time are then plotted along the abscissa and a series of points of the sine curve obtained by the usual graphic procedure.

It is the objective of this paper to introduce a simple apparatus which permits to carry out the construction of the sine curve by means of an experiment.

A circuit, consisting of a flashlight bulb, two small batteries, a switch and the necessary wire connections, is mounted on a wooden disc. The disc is fastened to a horizontal rod which can

rotate freely in the bearing surfaces of two uprights screwed onto a heavy board of wood. The rod supports a second disc which holds a few feet of string in a groove cut around its circumference. The device for projecting the rotary motion of the lighted bulb is made from a wooden box, open at one side and sufficiently large to cover the disc carrying the bulb. One of the boards of the box is provided with a number of small holes, arranged in a straight line and at definite intervals.* Pieces of straw, approximately two inches long, are placed into the holes and aligned carefully so that they protrude perpendicularly from the board.

After the rotary motion of the lighted bulb has been shown, the bulb is covered by the box so that the plane of the straws coincides with the plane of rotation of the bulb. A paper screen is placed in front of the straws and the disc rotated at a uniform rate, thus producing a simple harmonic motion of the dot of light on the screen.

In order to obtain a sine curve, a translatory motion of the lighted bulb parallel to the screen is superimposed upon its rotary motion. The apparatus is placed upon a low carriage, and the string, which leaves the grooved disc in a plane perpendicular to that of the screen, is led by way of two pulleys set at a right angle to a clamp fastened at the table. If the carriage is now moved along the screen, while a constant tension is maintained in the string, the dot of light visible on the screen will assume positions corresponding to a series of points of a sine curve. For a permanent record of this point by point construction, the positions of the dot of light are carefully marked on the screen by touching the latter with a brush, dipped in a suitable dye. The making of this record is facilitated by the fact that the design of the apparatus renders it unnecessary to move the carriage at a uniform rate in order to obtain a sine curve. As long as a constant tension is maintained in the string, the relationship between the translatory and rotary motions of the bulb will remain unchanged.

The experiment may be modified in a number of ways. Thus, arrangements can be made which permit a variation of the amplitude or period of vibration.

* Equidistant holes may be considered preferable for reasons of pedagogy, although a more pleasing picture of the sine curve is obtained if the holes are spaced according to the distances traveled by the projection of the rotating bulb during equal intervals of time.

NOTES FROM A MATHEMATICS CLASSROOM

Joseph A. Nyberg
Hyde Park High School, Chicago, Illinois

75. Definitions of the Trigonometric Ratios. When defining the ratios for angles larger than 90° two choices of notation are available. Some texts use the coordinates x, y, and r; and some draw a perpendicular MP to the initial side of the angle from a point P on the terminal side. I favor using OM, MP, and OP in the definitions. When determining the signs of the ratios in the various quadrants, the pupil who uses x, y, r must remember that x and y are sometimes negative, and there is nothing about the letters x and y that calls this fact to his attention. On the other hand, when the definition speaks of OM the pupil must look at two points, O and M, and his eye must travel from O to M thus reminding him that the line may be negative or positive.

76. Compass, Magnetic, and True Course. In pre-flight classes we consider problems that involve variation, deviation, compass course, magnetic course, and true course. Very few articles have been written to date about the pedagogy of this material, that is, how best to teach it. We need discussion of how to teach these concepts just as we discuss how best to teach multiplication of signed numbers or how to develop deductive reasoning in geometry.

When defining the angles mentioned above, many of the definitions in textbooks could be improved. Instead of saying merely that variation is the number of degrees by which a compass needle turns away from true north, I would say:

Variation is the angle between the line pointing north and the line pointing to the magnetic pole. This angle is measured *from* the north line *towards* the other line.

Likewise, deviation is the angle between the line pointing to the magnetic pole and the direction in which the compass needle points. This angle is measured *from* the line pointing to the magnetic pole *towards* the other line.

Also, compass course is the angle between the direction of the compass needle and the course or track of the plane. The angle is measured *from* the first line *towards* the second.

There is an advantage in stating that the angles are to be measured *from* a certain line *towards* a certain line: when measured clockwise, the angles are positive; measured counter-clock-

wise, the angles are negative. Further, when a pupil draws a figure for some problem, the pupil should draw an arc and put an arrow head at the terminal side of the angle. The advantage of this form of the definitions becomes apparent when we try to state the rules telling how to change from true course to compass course or vice versa. In the preflight classes I have experimented with mnemonics like "Can Dead Men Vote Twice?" in *Buchan's* text, and "The Variation Makes Daily Changes," in the *Pope-Otis* text, and with the C_c, C_n, C_m formulas in other texts. I prefer the simple relation:

$$V+D+C=T,$$

meaning: Variation + Deviation + Compass course = True course. Then if any three of these numbers are given, the fourth can be found by simple substitution. As in any algebraic formula, due regard must be paid to the plus and minus angles. For example, if the Variation is 15° E, Deviation is 3° W, and the compass course is 60°, then $15-3+60=T$. If C is unknown, then the equation is solved for C *after* the substitution. The mnemonics, of course, aim to substitute mental arithmetic for written work; but the substitutions in the formula can also be made mentally. We teach the use of signed numbers, teach pupils to use equations, and then when this knowledge could be used, we seem to shy away from it and resort to clumsy rules of thumb.

Likewise, the clumsy rules for finding the magnetic course can be reduced to the formula $D+C=M$.

77. The Tendency to Exhaust a Topic. Last month I urged the adoption of a slogan like "a partial success with significant work is more to be desired than a larger success with trivial work." Assuming that there is some truth to this statement, we should consider the questions: What is the definition of *trivial?* How did the trivial work get into our courses? I can suggest an answer to the last question. When planning any course, two of the hampering forces that every teacher and writer must fight are (1) the tendency to exhaust a topic, and (2) the tendency to anticipate every difficulty a pupil might face.

I can illustrate the first tendency from the field of elementary algebra if the reader is willing to admit that the main object of algebra is to teach a pupil how to state a problem in algebraic language and how to solve the resulting equations. This ability grows slowly. A start can be made in September; there is a slight

advance in October; a little more is learned in November; some more in December. The pupil will never acquire the technique if we spend two or three months on formal operations, and then plunge into verbal problems for a week; drop the matter for two or three months, and then try to finish the topic in a concentrated dose. The work must be spread from September to June.

During the first semester the problems lead to such equations as:

$$7x=5(24-x) \qquad 45x+60(90-x)=90\times 50$$
$$\tfrac{1}{2}x+\tfrac{1}{4}(x-3)=\tfrac{5}{6} \qquad c+.12c=224$$

or sets like $\quad y=2x+3, \quad 5x+10y=130$

To solve such equations the pupil does *not* need training with such exercises as:

Add
$$\begin{array}{r} 15y^3 \\ -12y^3 \\ 8y^3 \\ \hline \end{array} \qquad \begin{array}{r} 5(a-b) \\ -7(a-b) \\ -2(a-b) \\ \hline \end{array} \qquad \begin{array}{r} 2x^2-5x+8 \\ -3x^2+4x-6 \\ x^2-\ x+9 \\ \hline \end{array}$$

From $\quad 2y^2-6y+7$ subtract $\quad -5y^2+4y-2$.

Find the value of $\quad 3a^2-2ab+5b^2$ if $a=-3,\ b=2$.

Multiply $\quad 3x^4$ by $-5x^2y$; $\quad 2xy-6x^2$ by $-5xy$;
$3x-4y$ by $5x+6y$; $\quad (-3a^3b^4)^2=?$

Divide $\quad -6a^2b$ by $2ab$; $\quad -8c^3d^3$ by $2cd^2$.

On the other hand, to solve the equations shown above, the pupil needs to know only (1) how to add, multiply, divide, and subtract signed numbers like -2, $+3$, -4, $.6$, $-\frac{1}{4}$; (2) how to use parentheses like $5(24-x)$ and $-(8-x)$; and (3) how to add terms like $5x-6x+7x$.

Suppose, then, that at a certain stage the teacher begins the teaching of addition of signed numbers. The work must begin early so that the verbal problems may be spread over a long period. In my experience any class can learn to add in a single class period. The work is limited to the numbers like those previously mentioned and nothing is said about such expressions as $5x-6x+7x$. The term $5x$ implies a multiplication and the class has not yet studied multiplications. The usual course ignores the fact that $5x$ is a multiplication and plunges ahead with $2(a+b)$ and $-3(a+b)$ and other similar expressions. It is true that the pupil can give the right sum because he thinks of it as 2 apples and bananas added to -3 apples and bananas.

The teacher, having started addition of signed numbers, feels that this is the time to enlarge, if not exhaust, the topic and to do *every* possible kind of addition that ever might arise during the next month or months, or years.

Likewise, the multiplication of the simple necessary numbers can be learned in a single (the next) class period. But the teacher may feel that such an important topic as multiplication deserves more attention. And so the class studies $-2x$ times $3y^2$, and $4x$ times $2x-3y$, and then $4x-5y$ times $2x-3y$, and so forth until the topic of multiplication has been exhausted. But as far as equations are concerned, all that the class needed was the multiplication of numbers like 2, -3, -4, and other simple integers and fractions.

And thus the study of problems and their equations gets pushed farther and farther into the future. The temptation to exhaust each topic was too strong. These extensions of multiplication and addition are needed in the course but they can be postponed until after a start has been made on problems and equations. Their introduction in the wrong place makes them trivial. Some teachers justify this trivial work on the ground that it is the only kind of work that the below-average pupils can do. And to this argument the answer should be "a partial success with significant work is more to be desired than a larger success with trivial work."

78. For the Class in Pedagogy. A class is proving: Two points equidistant from the ends of a line determine the perpendicular bisector of the line. Let C and D be the points that are equidistant from A and B. (To save metal I let the reader draw his own figure.) In the usual proof, we first prove $\triangle ACD \cong \triangle BCD$ in order to get $\angle ADC = \angle BDC$.

Suppose that at this stage a pupil says, "You do not need to prove those triangles congruent; we know that $\angle ADC = \angle BDC$ because we bisected $\angle ADB$." When I first heard this argument I answered that we had not bisected $\angle ADB$; we had made $AD = DB$ and $AC = BC$. But the pupil continued, "As soon as you drew AD and DB you had an angle ADB. To bisect an angle, you get two points (in this case A and B) one on each side of the angle and such that $AD = DB$. Then you use A and B as centers and draw two arcs with the same radius, intersecting at C. This you did. Hence you really bisected $\angle ADB$."

What should the teacher then say?

EDWIN W. SCHREIBER, HISTORIAN

The Central Association of Science and Mathematics Teachers, through its Board of Directors at the Annual Meeting on November 26, 1943, created a new office, namely, that of Historian, and appointed Edwin W. Schreiber as the Association's first official historian.

Mr. Schreiber is well known to the members of the Central Association of Science and Mathematics Teachers, having joined the organization in November, 1918. SCHOOL SCIENCE AND MATHEMATICS has been coming to his desk since 1915. He has served two three-year terms on the Board of Directors, 1930–31–32, and again in 1940–41–42. During the year 1943 he was Vice-President of the Association. His first published paper appeared in our Journal, in May, 1919, when he was Head of the Department of Mathematics at Proviso Township High School, Maywood, Illinois. Since that time he has contributed many articles to SCHOOL SCIENCE AND MATHEMATICS. Always vitally interested in the Mathematics Section of the Association, he has contributed many papers before this Section, and has served as Vice-Chairman and Chairman in 1927–28.

He was born and raised in Saginaw, Michigan; received his training at the University of Michigan, the University of California at Berkeley, and at the University of Chicago. He belongs to many professional organizations both in this country and abroad. He is a Fellow of the American Association for the Advancement of Science and a charter member of the National Council of Teachers of Mathematics and has been its Secretary-Treasurer since 1929. He is also a charter member of the History of Science Society and has served on its committees. His teaching experience has been wide and varied: Illinois, Arizona, Pennsylvania, Michigan, and Wisconsin. He has been a member of the Mathematics Department of the Western Illinois State Teachers College, Macomb, Ill., for the past fifteen years.

Mr. Schreiber deems it a high honor to serve the Association as its first historian.

GLEN W. WARNER, *Editor*

THE CENTRAL ASSOCIATION OF SCIENCE AND MATHEMATICS TEACHERS ROSTER OF OFFICERS FROM THE FIRST MEETING, NOV. 28, 1902 TO NOV. 26, 1943

Compiled by Edwin W. Schreiber, Historian

Abells, Harry D. (C) Morgan Park Military Academy, Chicago. VP17, P18

*Adams, Charles F. (P) d.15, Central High School, Detroit. 2ndVP02

Ammermann, Charles (M) McKinley High School, St. Louis. AT13

Atkin, Edith I. (M) State Normal University, Normal, Ill. CS21

Ayres, Franklin H. (P) Central High School, Kansas City, Mo. 1stVP02

Baker, Arthur O. (B) John Marshall High School, Cleveland. D37, 41, 42, 43
Bemisderfer, F. R. (C) East Technical High School, Cleveland. D30, 31, 32
Bowden, Garfield A. (C) University School, Cincinnati. AT22
Bower, Ernest O. (P) East Technical High School, Cleveland. D32, VP33, D34, 35, 38, 39
Breslich, Ernst R. (M) School of Education, Univ. of Chicago. VP26, P27, HM41-
Brookley, A. C. (B) Thornton Twp. High School, Harvey, Ill. D40, 41, 42
*Butler, William M. (P) d.23, Yeatman High School, St. Louis. VP18

Caldwell, Otis W. (B) State Normal School, Charleston, Ill. P05, P06
Cantwell, T. O. (B) Crane Junior College, Chicago. D28, BM28
Carnahan, Walter H. (M) Shortridge High School, Indianapolis. D33, 34, 35, 36, 37, 38
Cavanaugh, A. Wirth (M) Lewis Institute, Chicago. S15, 16, 17, 18
Chaplin, Jessie F. ( ) West High School, Minneapolis. AS14, VP15
Christofferson, H. C. (M) Miami University, Oxford, Ohio. D43, 44
Christy, E. W. (I. A.) Board of Education Bldg., Cincinnati. VP35
Church, Frances (C) East High School, Des Moines, Iowa. D29, 30
Coats, Amy L. (M) Northwestern High School, Detroit. CS28
*Cobb, Herbert E. (M) d.38, Lewis Institute, Chicago. P11, P12
Comstock, Clarence E. (M) Bradley Poly. Inst., Peoria. P07
Condit, Ira S. (M) Iowa Teachers College, Cedar Falls. AS13
Crandall, G. H. (M) Culver Military Academy, Culver, Ind. AT19

Davis, Alfred (M) Soldan High School, St. Louis. P22
Davis, Ira C. (C) University High School, Madison, Wis. AT24, 25, D33, 34, 35, 37, P38, D39
Dickman, Joseph E. (V.E.) Board of Education, Chicago. D42, 43, 44
Donecker, F. C. ( ) Crane Tech. High School, Chicago. AS-T12
Douglass, S. A. ( ) Central High School, St. Louis. AS-T07, 08
Downing, Elliott R. (B) School of Education, Univ. of Chicago. P25, D28

Eikenberry, W. L. (B) University High School, Chicago. S13
Eisenhard, G. B. (P) Culver Military Academy, Culver, Ind. D31, 32, 33

Foberg, J. Albert (M) Crane Tech. High School, Chicago. P20
Frank, O. D. (B) University High School, Chicago. D32, 33, 34, 35, P36, D37
*Franklin, George T. (C) d.37, Lane Tech. High School, Chicago. D36, 37
Frey, Franklin (M) Waukegan Twp. High School, Waukegan, Ill. D39, 40, VP41
Fuchs, Christine K. (B) Hyde Park High School, Chicago. D31, 32, 33

Georges, Joel S. (M) Wright Junior College, Chicago. D35, 36, 37, 38, 39, 40, P42, D43
Gillet, Harry O. (M) School of Education, Univ. of Chicago. S19, 20, VP21
Gingery, W. G. (M) Shortridge High School, Indianapolis. T24, 25, 26, 27, VP29, D29, P30, D32, 33, 34, 35, 36, 37
Goodell, Frank E. (CP) North High School, Des Moines, Iowa. AS-T09 VP13, VP25, P26
Gorton, Frederick R. (P) State Normal College, Ypsilanti, Mich. VP20
Grabau, H. A. (B) Lincoln High School, Des Moines, Iowa. D39, 40, 41
Gugle, E. Marie (M) Ass't. Supt. Columbus, Ohio. VP14, P17

Hadley, Joel W. (B) Shortridge High School, Indianapolis. VP34
Hall, Lewis L. (P) Morgan Park High School, Chicago. T20, 21
Hanske, C. F. (C) Emmerick Man. Train. High School, Indianapolis. D41, 42, 43
*Harley, Theodore Lincoln (P) d.30, Hyde Park High School, Chicago. VP22
Hart, Walter W. (M) University High School, Madison, Wis. P21, D28, 29, 30, 31, 32, 33, 34, 35, 36, HLM37–
Hawkins, V. D. (P) Technical High School, Cleveland. AS-T10
Hethershaw, Lillian (E.S.) Drake University, Des Moines, Iowa. D37, 38
Hewitt, Glenn F. (M) Von Steuben High School, Chicago. D41, 42, 43
*Hildebrand, Louis Ernest (B) d.37, New Trier Twp. High School, Winnetka. VP28, D28
Holt, Clyde W. (C) East Technical High School, Cleveland. D34, 35, 36
*Holtzman, Clarence Lee (B) d.31, Waller High School, Chicago. VP23, P24
Howard, Russell S. (P) Lyons Twp. High School LaGrange, Ill. AT28
Howe, Clayton M. (P) Withrow High School, Cincinnati, Ohio. D38, 39

Inks, Edith (M) Oak Park High School, Oak Park, Ill. AS29
Isenberger, Jerome (B) Nicholas Senn High School, Chicago. P19, D29, 30, 31, 33, 34, 35

Johnson, Geraldine Reep (B) Washington High School, Indianapolis. D43, 44, 45
Johnson, John T. (M) Chicago Teachers College, Chicago. D43, 44, 45
*Jones, Franklin T. (P) d.43, University School, Cleveland. P08

Kambly, Paul E. (GS) Univ. Experimental Schools, Iowa City. D43, 44
Kelsey, Theodore D. (C) Cleveland High School, St. Louis. VP24, D37, 38
Kinney, J. M. (M) Wilson Junior College, Chicago. VP38, D39, 40
Krenerick, H. Clyde (P) North Division High School, Milwaukee. AT16, 26, VP30, D31, 32, 33, 36, 37, 38

Lambert, Ray (P) Walnut Hills High School, Cincinnati. D40
Lehman, D. A. (M) Goshen College, Goshen, Ind. CS18, 19
Leonard, C. J. (M) Southeastern High School, Detroit. D37, 38, 39, VP40
*Linebarger, Charles E. (P) d.37, Lake View High School, Chicago. S02, 03, 04, D28, E01–04
Long, Edith (M) Lincoln High School, Lincoln, Nebraska. VP16

Mahaffey, Evan L. (B) High School of Commerce, Columbus, Ohio. AT17
Marlatt, Abby L. (HE) University of Wisconsin, Madison, Wis. CS20
Martin, Ersie S. (P) Arsenal Tech. High School, Indianapolis. AT27, T28, 29, 30, 31, 32, 33, 34, 35, 36, D38, 39, 40
Massey, E. L. (GS) Board of Education, Detroit, Mich. D41, 42, 43
Mayfield, John (BC) University High School, Chicago. D43, 44, 45
McAtee, Veva (BC) George Rogers Clark School, Hammond, Ind. D40,41, 42
McAuley, M. Faith (HE) High School, St. Charles, Ill. AS15
McClellan, John H. (P) Harrison Tech. High School, Chicago. T16, 17, 18, 19
McDonald, J. Russell (M) J. Sterling Morton High School, Cicero, Ill. D32, 33, 34
McEvoy, S. Aleta (P) Rockford High School, Rockford, Ill. CS25
Melrose, Mary (ES) Board of Education, Cleveland, Ohio. D39

Metcalf, Harold H. (C) Oak Park High School, Oak Park, Ill. S36, S-T37, 38, S39, 40, P41, D42, S43
Milford, Harvey M. (P) Edwin Denby High School, Detroit. D34, 35, VP36
*Millis, James F. (M) d.17, Francis W. Parker School, Chicago. S-T10, 11, P13
Mull, Lewis B. ( ) High School, Ottumwa, Iowa. AT14

Neal, Nathan A. (GS) East Tech. High School, Cleveland. D36, 37, 38, VP39, P40, D41
Newhall, Charles W. (M) Shattuck School, Fairibault, Minn. CS16
Nyberg, Joseph A. (M) Hyde Park High School, Chicago. D28, 29, 30, 31, 32

Obenauf, Homer A. (M) Culver Military Academy, Culver, Ind. AT23
Oestreicher, Milton D. (M) Francis W. Parker School, Chicago. D42, 43, 44

Park, R. Emerson (GS) Oak Park High School, Oak Park, Ill. D43, 44, 45
Parsons, Chas. W. D. (P) Evanston Twp. High School, Evanston, Ill. T06, S-T07
*Peterson, Allan (P) d.26, East High School, Des Moines, Iowa. CS17
Peterson, George K. (C) North High School, Sheboygan, Wis. D40, 41, 42, P43
Phillips, M. J. W. (P) Lincoln High School, West Allis, Wis. D29, T42

Radcliffe, H. H. ( ) High School, Connersville, Ind. AT15
Rhodes, Joseph W. (B) Senior High School, Beloit, Wis. D42, 43, 44
*Roecker, William F. (CP) d.42, Boys Tech. High School, Milwaukee, Wis. AT21, VP27, P28, D28, S29, 30, 31, BM29–42, D30, 31, 32, T39, 40, 41, 42
Ross, DeForrest (P) High School, Ypsilanti, Mich. D29, 30
Royt, Pauline (GS) Horace Mann Jr. High School, West Allis, Wis. D39, 40, 41
Rush, Jesse J. (M) West High School, Cleveland, Ohio. AS32

Sangernebo, Marie (Mrs. Wilcox), (M) Washington H. S., Indianapolis. AS30, D35, 36, 37, 38, P39, D40
Schreiber, Edwin W. (M) Western Ill. State Teachers College, Macomb. D30, 31, 32, D40, 41, 42, VP43, H43–
*Schwede, Charles W. (GS) Senn High School, Chicago. CS23
Shepard, Winnafred J. (B) Proviso Twp. High School, Maywood, Ill. CS26, S27
Simon, R. B. (B) Western Reserve Academy, Hudson, Ohio. VP37
*Smith, Charles H. (P) d.26, Hyde Park High School, Chicago. P02, 03, 04, E05–26
Smith, Herbert R. (C) Lake View High School, Chicago. T14, 15, P16, D28, 29, 30, 31
*Smith, James H. (G) d.37, Austin High School, Chicago. P09, 10, D29, 30
Smith, Villa B. (G) Cleveland School of Education, Ohio. D33, 34, VP42
Soliday, Ray C. (C) Oak Park High School, Oak Park, Ill. S41, 42, T43–, BM43–
Spicer, C. E. (P) Twp. High School, Joliet, Ill. AS-T11, S-T12, T13, P15
Stewart, Margery (C) New Trier Twp. High School, Winnetka, Ill. CS27
Stone, Charles A. (M) University High School, Chicago, VP32, P33
Sykes, Mabel (M) Bowen High School, Chicago, D28

Teeters, W. R. (C) Board of Education Bldg., St. Louis. D34, 35, 36, P37, D38, 39, 40, 41
Tillman, E. S. ( ) High School, Hammond Ind. AT20
Tower, Willis E. (P) Englewood High School, Chicago. S-T08, 09, P14
*Turton, Charles M. (P) d.37, South Chicago H. S., Chicago. S05, 06, BM05–28, D29, 30, 31

Urbancek, J. J. (M) Chicago Teachers College. D41
Ullrich, Fred T. (B) Normal School, Platteville, Wis. VP19
Ulrich, Katherine (Mrs. Isenbarger), (G) Oak Park H. S., CS24, VP31, D32, 33, P34, 35, D36

Van Hise, Ira N. (G) Chicago Normal College. T22, 23
Vordenberg, Kenneth (CP) Washington Jr. High School, Cincinnati. D42

Wade, Frank B. (C) Shortridge High School, Indianapolis. P23
Wadleigh, M. F. ( ) South Division High School, Milwaukee, Wis. AT18
Warner, Glen W. (P) Englewood High School, Chicago. S21, 22, 23, 24, E26–43–, D29, 30, P31, HM41–
Webb, Charles S. (P) Beaumont High School, St. Louis, Mo. D36
Weckel, Ada L. (B) Oak Park High School, Ill. CS22, S25, 26, D28, P29, D30, 31
Williams, E. Marsh (PG) La Grange High School, Ill. T05
Woodruff, E. C. (P) Lyons Twp. High School, LaGrange, Ill. T02, 03, 04
*Wynne, Ross B. (B) d.36, Crane Junior College, Chicago. AS31, S32, 33, 34, 35, 36

KEY TO ABBREVIATIONS:

AT, Assistant Treasurer; AS, Assistant Secretary; AS-T, Assistant Secretary-Treasurer; (B), Biology; BM, Business Manager of Journal; (C) Chemistry; CS, Corresponding Secretary; D, Director; d., died; (ES), Elementary Science; E, Editor of Journal; (GS), General Science; HM, Honorary Member; HLM, Honorary Life Member; (HE), Home Economics; H, Historian; (I.A.), Industrial Arts; (M), Mathematics; P, president; (P), Physics; S, Secretary; S-T, Secretary-Treasurer; T, Treasurer; VP, Vice-President; (V.E.), Visual Education. Numbers following letters indicate the period of time in office.—NOTE: The institutional address given is of the date when the member first became an officer.

* Deceased

WELLESLEY COLLEGE SUMMER SCHOOL

In connection with the Wellesley College Summer School of Techniques courses will be given in several of the science departments. Of special interest to high school teachers will be a course in general physics intended primarily as a refresher course for teachers now teaching other subjects who wish to prepare for the teaching of physics and for others who wish a more thorough foundation. The lectures will be abundantly illustrated with experiments, many of which can be easily duplicated with the usual preparatory-school equipment. Methods of use of moving pictures will be demonstrated. In the laboratory the range of experiments will be such as to permit comparisons of the accuracy of different methods of measurement and the pedagogic value of each.

PROBLEM DEPARTMENT

CONDUCTED BY G. H. JAMISON
State Teachers College, Kirksville, Mo.

This department aims to provide problems of varying degrees of difficulty which will interest anyone engaged in the study of mathematics.

All readers are invited to propose problems and to solve problems here proposed. Drawings to illustrate the problems should be well done in India ink. Problems and solutions will be credited to their authors. Each solution or proposed problem sent to the Editor should have the author's name introducing the problem or solution *as on the following pages.*

The editor of the department desires to serve its readers by making it interesting and helpful to them. Address suggestions and problems to G. H. Jamison, State Teachers College, Kirksville, Missouri.

SOLUTIONS AND PROBLEMS

Note. Persons sending in solutions and submitting problems for solutions should observe the following instructions.

1. Drawings in India ink should be on a separate page from the solution.

2. Give the solution to the problem which you propose if you have one and also the source and any known references to it.

3. In general when several solutions are correct, the one submitted in the best form will be used.

LATE SOLUTIONS

1850. *Ted Bains, Oneonta, Ala.; Lizzie Mullalah, Quebec, Canada; Walter R. Warne, Fayette, Mo.*

1856. *Robert Elliott, Jr., Mercersburg, W. Va.; Dorothy C. Hand, Clarks Summit, Pa.; Sigmund Chamer, New York City.*

1857. *M. Kirk, West Chester, Pa.; Dorothy C. Hand, Clarks Summit, Pa.*

1852. *Walter R. Warne, Fayette, Mo.*

1861. *Proposed by Alan Wayne, New York City.*

If r and R are the inradius and circumradius, respectively, of triangle ABC, show that

$$\cos A+\cos B+\cos C=\frac{(R+r)}{R}\cdot$$

Solution by Ralph Mansfield, Chicago

From trigonometry

$$2R=\frac{a}{\sin A} \quad\text{and}\quad r=\frac{a\sin\frac{B}{2}\sin\frac{C}{2}}{\cos\frac{A}{2}}\cdot$$

By addition and a multiplication, we have

$$2(R+r)=\frac{a\left[1+4\sin\frac{A}{2}\sin\frac{B}{2}\sin\frac{C}{2}\right]}{2\sin\frac{A}{2}\cos\frac{A}{2}}.$$

Also from trigonometry

$$1+4\sin\frac{A}{2}\sin\frac{B}{2}\sin\frac{C}{2}=\cos A+\cos B+\cos C.$$

Hence by substitution:

$$2(R+r)=\frac{a(\cos A+\cos B+\cos C)}{\sin A}$$

$$=2R(\cos A+\cos B+\cos C),\quad \text{using}\quad \sin A=\frac{a}{2R}.$$

Hence

$$\frac{R+r}{R}=\cos A+\cos B+\cos C.$$

Solutions were also offered by M. Kirk, West Chester, Pa.; Hugo Brandt, Chicago; Jonathon Scoby, East Romulus, N. Y.; Walter R. Warne, Fayette, Mo.; Helen Scott, Baltimore, Md.; D. F. Wallace, St. Paul, Minn.; A. E. Gault, Peoria, Ill.; and the proposer.

1862. *Proposed by M. Kirk, West Chester, Pa.*

How long is an army column if an inspecting officer travels the length of the column and back while the column is traveling its own length. The total distance covered by the officer is $4(1+\sqrt{2})$ miles.

Solution by Hugo Brandt, Chicago

Taking for time unit the time it takes the army (length a) to move the distance a, its speed is a, the officer's speed $s=4(1+\sqrt{2})$, his advance speed relative to the army: $s-a$, and $(s+a)$ on the trip back. Hence the times for these 2 partial trips $a/a-a$ and $a/s+a$, which together make up the time unit 1; therefore

$$\frac{a}{s-a}+\frac{a}{s+a}=1$$

$$2as=s^2-a^2$$

$$a^2+2as=s^2$$

$$a=-s+\sqrt{2s^2}=s(\sqrt{2}-1).$$

Evaluation:

$$a=4(1+\sqrt{2})(\sqrt{2}-1)=4\ \textit{miles}.$$

Solutions were also offered by Helen M. Scott, Baltimore, Md.; Charles P. Louthan, Columbus, Ohio; Wm. A. Richards, Berwyn, Ill.; A. E. Gault, Peoria, Ill.; W. R. Smith, Sutton's Bay, Wis.; and the proposer.

1863. *Proposed by M. Kirk, West Chester, Pa.*

Find the first quadrant value of θ (exact) if

$$\theta=\text{arc}\cos\frac{1}{\sqrt{6}+\sqrt{2}}.$$

Solution by D. F. Wallace, St. Paul, Minn.

$$\frac{1}{\sqrt{6}+\sqrt{2}}=\text{approximately } .25882.$$

Therefore cos θ is about .25882, which indicates that θ is an angle of about, if not exactly, 75°.

To test whether or not θ is exactly 75° let

$$\begin{aligned}\cos 75^\circ &= \cos(45^\circ+30^\circ)\\ &= \cos 45^\circ \cos 30^\circ - \sin 45^\circ \sin 30^\circ\\ &= \frac{\sqrt{3}-1}{2\sqrt{2}}\\ &= \frac{1}{\sqrt{6}+\sqrt{2}}.\end{aligned}$$

Hence

$$\theta=75^\circ.$$

Solutions were also offered by A. B. Curtis, St. Louis, Mo.; Hugo Brandt, Chicago; James Sample, Romulus, N. Y.; Alan Wayne, Flushing, N. Y.; Jessie Chapman, Victor, N. Y.; Mr. and Mrs. W. R. Warne, Fayette, Mo.; Sigmund Chamer, New York City; Dorothy Hand, Clarks Summit, Pa.; Helen M. Scott, Baltimore, Md.; Irving Lindsey, Alexandria, Va.; A. E. Gault, Peoria, Ill.; William A. Richards, Berwyn, Ill.; Charles P. Louthan, Columbus, Ohio; Gratia L. Rice, Albany, N. Y.; and the proposer.

1864. *Proposed by Norman Anning, University of Michigan.*

If $a+b+c=0$, show that

$$\begin{vmatrix} bc & ca & ab\\ ab & bc & ca\\ ca & ab & bc\end{vmatrix}$$

is a perfect cube.

Solution by Aaron Buchman, Buffalo, N. Y.

Let

$$N=\begin{vmatrix} a & c\\ -a-b & b\end{vmatrix}=\begin{vmatrix} b & a\\ -b-c & c\end{vmatrix}=\begin{vmatrix} c & b\\ -c-a & a\end{vmatrix}=ab+bc+ca. \qquad (1)$$

Using the given relation, $a+b+c=0$, replace the binomial in each determinant by its equal, and

$$N=\begin{vmatrix} a & c\\ c & b\end{vmatrix}=\begin{vmatrix} b & a\\ a & c\end{vmatrix}=\begin{vmatrix} c & b\\ b & a\end{vmatrix}=ab+bc+ca. \qquad (2)$$

Let the given determinant be D. Add the second and third rows of D to the first row, replace $ab+bc+ca$ by N, and

$$D=\begin{vmatrix} N & N & N\\ ab & bc & ca\\ ca & ab & bc\end{vmatrix}. \qquad (3)$$

Expand (3) by minors of the first row, remove the common factors from the columns of each minor, and

$$D=Nbc\begin{vmatrix} c & a \\ a & b \end{vmatrix}+Nca\begin{vmatrix} a & b \\ b & c \end{vmatrix}+Nab\begin{vmatrix} b & c \\ c & a \end{vmatrix}. \tag{4}$$

Replace each determinant of (4) by N, and

$$D=N^2(bc+ca+ab). \tag{5}$$

Replace $bc+ca+ab$ by N, and

$$D=N^3. \tag{6}$$

Solutions were also offered by A. B. Curtis, St. Louis, Mo.; Hugo Brandt, Chicago; Ralph Mansfield, Chicago; Wm. A. Richards, Berwyn, Ill.; A. E. Gault, Peoria, Ill.; M. Kirk, West Chester, Pa.; W. R. Warne, Fayette, Mo.; Irving Lindsay, Alexandria, Va.

1865. *Proposed by Howard D. Grossman, New York City.*

The map of a city contains m north-south streets and n east-west streets. (1) How many rectangles are on the map? (2) How many shortest distinct routes are possible from one corner of the city to the diagonally opposite corner?

Solution by Hugo Brandt, Chicago

1. The rectangles are formed by m N-S streets and n E-W streets, their width from E to W varying from 1 to $(m-1)$ blocks; from N to S from 1 to $(n-1)$ blocks. In E-W direction: for width 1 block, there are $(m-1)$ rect.; for width 2 blocks there are $(m-2)$ etc.; for width $(m-1)$ blocks there is 1 rectangle. Hence the total of these:

$$\sum_1^{m-1} m=\frac{m(m-1)}{2}$$

and since for each item of this sum, the width in N-S direction may vary, similarly in $n(n-1)/2$ ways the total number of rectangles is

$$\tfrac{1}{4}m\cdot n(m-1)(n-1).$$

2. In going from the S-W corner to the N-E corner of the plot, we must go North $(n-1)$ blocks, and East $(m-1)$ blocks; there are in these variations $(m-1)+(n-1)$ elements, the permutations of which would be $(m+n-2)!$ were it not for the fact that the $(m-1)$ elements are all the same, all East, and the $(n-1)$ elements are all North, reducing the variations to the number

$$\frac{(m+n-2)!}{(m-1)!(n-1)!}.$$

Solutions were also offered by Wm. A. Richards, Berwyn, Ill.; Aaron Buchman, Buffalo, N. Y.; W. R. Smith, Gainesville, Fla; M. Kirk, West Chester, Pa.

1866. *Proposed by Fred Jones, Scott's Corner, N. Y.*

Solve for x

$$\sqrt{\frac{x+a}{x}}+2\sqrt{\frac{a}{x+a}}=b^2\sqrt{\frac{x}{a+a}}.$$

Solution by Sigmund Chamer, New York City (High School of Science).

$$\sqrt{\frac{x+a}{x}}+2\sqrt{\frac{a}{x+a}}=b^2\sqrt{\frac{x}{x+a}}.$$

Multiplying by

$$\sqrt{x}\sqrt{x+a}$$

$$x+a+2\sqrt{ax}=b^2x. \tag{1}$$

Since

$$(\sqrt{x}+\sqrt{a})^2=x+a+2\sqrt{ax} \tag{2}$$

$$(\sqrt{x}+\sqrt{a})^2=b^2x \tag{3}$$

and

$$\sqrt{x}+\sqrt{a}=b\sqrt{x}. \tag{4}$$

$$\sqrt{a}=(b-1)\sqrt{x},$$

from which

$$\sqrt{x}=\frac{\sqrt{a}}{(b-1)^2}$$

and

$$x=\frac{a}{(b-1)^2}.$$

Editor's Note: Several solutions included $a/(b+1)^2$ as a root. It results from using the minus sign in (4), which is not permissible, since the left member is clearly positive.

Other solutions were offered by Helen M. Scott, Baltimore, Md.; Fred Jones, Scott's Corner, N. Y.; Wm. A. Richards, Berwyn, Ill.; John Drumhiller, Philadelphia, Pa.; A. E. Gault, Peoria, Ill.; Ralph Mansfield, Chicago; Hugo Brandt, Chicago; Niles Jones, Ovid Center, N. Y.; Mrs. W. R. Warne, Fayette, Mo.; Irene W. Van Riper, Scott's Corner, N. Y.; Belle Brokaw, East Rutland, Vt.; Peter Van Riper, McDuffietown, N. Y.; Carrie J. Wilson, Sheldrake, N. Y.; M. Kirk, West Chester, Pa.; A. B. Curtis, St. Louis, Mo.; Alan Wayne, Flushing, N. Y.; Paul F. Miller, Baltimore, Md.; Chas. P. Louthan, Columbus, Ohio.

HIGH SCHOOL HONOR ROLL

The Editor will be very happy to make special mention of high school classes, clubs, or individual students who offer solutions to problems submitted in this department. Teachers are urged to report to the Editor such solutions.

Editor's Note: For a time each high school contributor will receive a copy of the magazine in which the student's name appears.

For this issue the Honor Roll appears below.

1862. Carl Friedrich, Ford City, Pa.

1863. Howard Swick, Hammond, Ind.; Martin Davist, Bronx High School of Science.

1866. Werner Teutsch, Philadelphia, Pa.; Osius Bain, Quebec, P. I.; Robert H. Elliott, Jr. Mercersburg, Pa.; Martin Davist.

PROBLEMS FOR SOLUTION

1879. *Proposed by Pearl Yerkes, Fayette, N. Y.*

Solve the system

$$x^2+3x+y=73-2xy$$
$$y^2+3y+x=44.$$

1880. *Proposed by William Cox, Willard, N. Y.*

Solve for x:

$$(a-x)^4+(x-b)^4=(a-b)^4.$$

1881. *Proposed by Howard D. Grossman, New York City.*

Solve:

$$x^2-y=y^2-z=z^2-x=2.$$

1882. *Proposed by Alan Wayne, Flushing, N. Y.*

A square whose side is 3 is inscribed in a right triangle whose hypotenuse is 12, so that the right angle of the triangle is an angle of the square. Find the legs of the triangle.

1883. *Proposed by Aaron Buchman, Buffalo, N. Y.*

In circle O with fixed diameter AB and variable chord AC, extend AC through C to D, so that $CD=OA$. Draw OD. Bisect angle CAB and extend the bisector back through A to E, so that $AE=OD$. Find the locus of E

1884. *Proposed by Morris I. Chernofsky, New York City.*

If $a^2=bc$, prove that $a^5+b^5+c^5$ is divisible by $a+b+c$. (More generally, if $a^2=bc$, then $a^{2n+1}+b^{2n+1}+c^{2n+1}$ is divisible by $a+b+c$.)

BOOKS AND PAMPHLETS RECEIVED

TODAY'S GEOMETRY, by David Reichgott and Lee R. Spiller, *The New Haven High School, New Haven, Connecticut.* Revised Edition. Cloth. Pages xvi+400. 14.5×23 cm. 1944. Prentice-Hall, Inc., 70 Fifth Avenue, New York, N. Y. Price $1.96.

THE CHEMISTRY OF SYNTHETIC SUBSTANCES, by Dr. Emil Dreher. Cloth. 103 pages. 13.5×21 cm. 1943. The Philosophical Library, Inc., 15 East 40th Street, New York 16, N. Y. Price $3.00.

BASIC AIR NAVIGATION, by Elbert F. Blackburn, *Chief Navigation Instructor, Atlantic Division, Pan American Airways System.* Cloth. Pages vii+300. 14×22.5 cm. 1944. McGraw-Hill Book Company, Inc., 330 West 42nd Street, New York, N. Y. Price $3.00.

A GUIDE TO NAVAL AVIATION, by Lt. Wallace W. Elton, USNR, *Senior Instructor;* Lt. Alfred H. Driscoll, USNR; Robert N. Burchmore, USNR and Lt. Gray B. Larkum, USNR, *Instructors, Introduction to Naval Aviation, Naval Training School, (Indoctrination), U. S. Naval Air Station, Quonset Point, R. I.* Cloth. Pages ix+296. 13×21 cm. 1944. McGraw-Hill Book Company, Inc., 330 West 42nd Street, New York, N. Y. Price $2.50.

MATHEMATICS FOR NAVIGATORS, by Delwyn Hyatt, Commander, U.S.N. (Ret.), *Head of the Department of Seamanship and Navigation, United States Merchant Marine Academy, Kings Point, New York,* and Bennett M. Dodson, Commander, U.S.N.R., *Commanding Officer, United States Merchant Marine Cadet Basic School, Pass Christian, Mississippi.* Cloth. Pages vii+106. 13×19.5 cm. 1944. McGraw-Hill Book Company, Inc., 330 West 42nd Street, New York, N. Y. Price $1.25.

PHYSICS, A TEXTBOOK FOR COLLEGES, by Oscar M. Stewart, *Professor of Physics, University of Missouri.* Fourth Edition. Cloth. Pages x+785. 14.5×22 cm. 1944. Ginn and Company, Statler Building, Boston, Mass. Price $4.00.

WEEJACK AND HIS NEIGHBORS (Stories about Animals of Field and Wood), by Carroll Lane Fenton. Cloth. 128 pages. 13.5×20.5 cm. 1944. The John Day Company, Inc., 2 West 45th Street, New York, N. Y. Price $1.75.

ESSENTIAL MATHEMATICS, by William David Reeve, *Teachers College, Columbia University.* Paper. Pages iv+282. 17×25.5 cm. 1943. The Odyssey Press, Inc., 386 Fourth Avenue, New York, N. Y. Price $1.32.

SERVICE IN THE ARMED FORCES. Victory Corps Series, Pamphlet No. 6. Paper. Pages ii+90. 19×25.5 cm. 1944. Superintendent of Documents, U. S. Government Printing Office, Washington, D. C. Price 20 cents.

BOOK REVIEWS

BELOVED SCIENTIST, by David O. Woodbury. Cloth. Pages xiii+358. 15×23.5 cm. 1944. McGraw-Hill Book Company, Inc., 330 West 42nd Street, New York, N. Y. Price $3.50.

Here is a book which every student of science will want to read. It should be placed in every school library so that our young people may early learn about this active man and the development of the electrical age. As a gift for your scientific friend it is unequaled. It is strange that scarcely a single high school or general college textbook of physics mentions Elihu Thomson's name but every home, office and shop using electric energy is indebted to his skill. Just one of his inventions need be mentioned—electric welding—to show his hand in the building of a battleship or the wire fence for a farm lot.

In writing this book Mr. Woodbury got his information from the men with whom Professor Thomson worked, the associates of his vacations in the mountains, the members of his family, executives of the General Electric Company, the professors and executives of M. I. T. and of Harvard University, and a host of others. Much of this book is about others, but it all adds up to an appreciation of the interesting life of Mr. Thomson and the development of a wonderful age. His early childhood in Manchester, England, the trip across the stormy Atlantic in 1858, his childhood days in Philadelphia, his rapid career through the grades completing his common school at the age of eleven—these are true stories every boy will enjoy reading. His formal education was completed at the age of seventeen when he graduated from Central High School. Soon afterward he became the "Adjunct to the Department of Chemistry" and in a few months was the junior partner of Houston and Thomson, a firm later known throughout

all America and Europe. His advanced education was obtained by individual study, which later was recognized by honorary degrees granted by the leading universities of America and England. Starting as a lecturer to great audiences in the Franklin Institute at the age of twenty-three he continued as a public lecturer for nearly sixty years. He was a leader in all the electrical developments of his time. Six hundred and ninety-two patents were granted to him. He was not only great in the field of electricity, but was an astronomer of no mean ability, he knew color photography, he ground and polished his own lenses and made his cameras, he studied quartz, he helped to plan the great 200-inch reflector for Mt. Palomar.

The book is filled with the interesting stories of his eventful life, and many incidents in the lives of his associates, his friends and his competitors. The industrial and scientific progress of the nation are so closely connected with his life that much of the history of the electrical development of the modern world fits into the story. This is one of the really great books of modern biography and scientific development, and worthy of a place in any library.

G. W. W.

PHYSICS, A TEXTBOOK FOR COLLEGES, by Oscar M. Stewart, *Professor of Physics, University of Missouri.* Fourth Edition. Cloth. Pages x+785. 14.5×22 cm. 1944. Ginn and Company, Statler Building, Boston, Mass. Price $4.00.

This new edition of a widely used text improves it materially. Although many sections of this book are the same as in the third edition, changes have been made where they were most needed. Greater emphasis is given to the mks system, especially in the discussion of the effect of forces on motion and in the section on work and energy. The newton has been placed in the table on page 110, a correction many teachers had previously directed their classes to make. Many topics have been added to the chapter on meteorology, material changes have been made in the chapters on Emission of Electrons and Atomic Transformation, and several new paragraphs have been added to the chapter on high frequency oscillation and electric waves. The discussions of sound and light are almost the same as in the third edition. Seven pages of tables have been added, supplying the student with logarithms and trigonometric functions. The problem lists have been revised and improved. Teachers and students who like the third edition will like the new volume better.

G. W. W.

MODERN PHYSICS, by Charles E. Dull, *Head of Science Department, West Side High School, and Supervisor of Science for the Junior and Senior High Schools, Newark, New Jersey.* Cloth. Pages x+598+xxv. 24×15.5 cm. 1943. Henry Holt and Company, New York City. $2.00.

The publishers have reissued *Modern Physics* as a revision of the 1939 edition. Actually, the few changes in the new edition are so few as to be difficut to find. Only the last few pages of the book, concerning the airplane, have been completely rewritten, and are extended to eighteen pages. In the remainder of the text, this reviewer found only two new half tones. Paging is identical in the two volumes save for the section mentioned above. Anyone acquainted with the older edition knows this one.

Those who are not acquainted with this high school text will find it worth consideration. It is well organized, it contains a minimum of debatable statements, and it is planned throughout to serve as a tool for teachers. Following recent trends in texts, it is comprehensive and lushly illustrated.

Several features are worth noting. Each unit begins with a preview. Each chapter has a short glossary on the first page. Each chapter closes with a list of terms for review, a summary, a set of questions, and two sets of problems. Subject matter items considered to be beyond the needs of a minimum course are starred. The book closes with tables and formulas, the last of which are amply defined.

One may quarrel with such items as the use of "power transmission," the casual treatment of cutting edges as wedges, and the statement that beginners find it easier to think of centrifugal forces. One may also dislike the tendency to treat theories as established facts. These items, however, are those of most existing high school texts, and do not detract from the relatively excellent standing of the book as a whole.

WALTER A. THURBER

EXPERIMENTS IN ORGANIC CHEMISTRY, by E. Wertheim, *Professor of Chemistry, University of Arkansas.* Waterproofed paper. Pages x+221. 34 illustrations. 1942. The Blakiston Company, 1012 Walnut Street, Philadelphia, Pa. Price $1.35.

This book was designed to accompany Dr. Wertheim's *Introductory Organic Chemistry* as a laboratory manual for the first semester of organic chemistry for students in home economics, agriculture, medicine, and dentistry. It shows the same careful preparation which characterizes the author's other texts.

The text contains sixty-two experiments covering a variety of topics. Most of the experiments are designed to illustrate the properties of representative types of compounds. In addition there are approximately fifteen preparations of pure organic compounds, well divided among gases, liquids, and crystalline solids. The last third of the manual is devoted to experiments with natural products and biochemical experiments of special interest to students in home economics and pre-medical curricula. There are enough experiments so that the individual instructor has a good choice of exercises for a one-semester laboratory course.

The detailed instructions on laboratory technique in the introductory pages of the manual are thorough and practical, and would be good reading for many advanced students in organic chemistry.

The experiments are provided with well-chosen questions. An additional feature of each experiment is an estimate of the amount of time it should take for completion by an average student.

ROBERT L. FRANK
University of Illinois

DYNAMICAL ANALOGIES, by Harry F. Olson, E.E., Ph.D., *Acoustical Research Director, RCA Laboratories, Princeton, New Jersey.* Cloth. Pages xi+196. 13.5×21.5 cm. 1943. D. Van Nostrand Company, Inc., 250 Fourth Avenue, New York, N. Y.

One of the first forward steps in the reproduction of speech and music came in about 1926 with the advent of the "Orthophonic Victrola." This major improvement was made possible because of two developments: namely, electrical recording, and a newly designed mechanoacoustical reproducing system. The great improvement in quality then obtained at both high and low frequency ends of the acoustical range was made possible by adapting the theory of electrical vibrating systems to the mechanical and acoustical vibrating systems. This was done largely through analogies between the systems from which the design engineer could develop a system of design for the mechanoacoustical transducer.

Although mechanical and acoustical devices are much older than the electrical networks, the development of the theory of the electrical vibrating circuit far overran that of the mechanical system. It then became useful to describe the behavior of the mechanoacoustical system in terms of the well developed electrodynamic concepts. The continued improvement of the quality of electromechanoacoustical systems as well as many advancements in mechanical vibration control, has been because of the collateral development of the electrical, the mechanical, and the acoustical theory.

Here is a book written expressly to show these analogies and to show how they can be used to develop the theory of the more complicated network or multielement system. It should be of great use in clarifying the concepts of the mechanoacoustical engineer provided he already has clear concepts of the alternating current element and network theory. The complex method of analysis is used along with the differential equations of motion and a knowledge of these is presupposed.

The subject matter is developed very thoroughly from the definition of terms and the comparison of simple circuit elements through to the more complex arrangements of multielement systems of corrective networks and transient control systems. Especially useful are the comparison tables given in Chapter 2. The use of diagrams to give aid in visualizing the arrangement of elements in each system along with the type of frequency response obtainable from the arrangement is very helpful.

Although the text is primarily for the advanced engineer or research physicist, many of the concepts and analogies should be part of the background knowledge of the teachers of physics and engineering at the lower levels. Many of these concepts can be obtained by a survey study of the definitions, comparisons, diagrams, and defining equations without the more rigorous study of the advanced analysis that would be required of the design engineer.

H. R. Voorhees
Wilson Junior College,
Chicago, Illinois

A Primer of Electronics, by Don P. Caverly, *Commercial Engineer, Sylvania Electric Products, Inc.* Cloth. Pages xi+235. 13×20 cm. 1943. McGraw-Hill Book Company, Inc., 330 West 42nd Street, New York, N. Y. Price $2.00.

A book for all persons who would like to know a little of the basic principles behind some of the common electrical devices in everyday home and commercial use.

Part I. Electric Current. The electron and its significance in relation to current flow, resistance, electrical pressure and power.

Part II. Magnetism. An interesting story, well illustrated by clear-cut diagrams, of the force of magnetism as applied to the generation of electric power stressing phase relation, counter E.M.F., inductance, capacitance, power factor, resonance, and harmonics in electrical circuits in common use.

Part III. Electromagnetic Radiation. This part of the story of electronics is introduced by a brief sound wave analogy and reference to the frontispiece, giving the range of electromagnetic radiations from .0001 to 100 million angstroms wave lengths and from 1 cm to 10 million meters wave lengths. This frontispiece chart, four pages long on logarithmic scale, is very valuable in the reading of Part III as well as Part IV. Reflection and refraction of light radiations, polarization, light measurement and color temperatures are clearly and entertainingly presented. Infra-red, ultraviolet, x-rays, gamma rays, cosmic rays, subsonic and supersonic oscilla-

tions, and radio waves with clear descriptions of the fundamentals of television and frequency modulation are the topics included in Part III.

Part IV. Basic Electronics. Each of the following electron tubes are briefly and clearly described in relation to the principles presented in the first three parts of this book: diode tube, triode tube, tetrodes, pentodes, beam-power tubes, incandescent lamps, gaseous-discharge light sources, hot-cathode fluorescent light sources including diagrams of fluorescent-lamp circuits and starters. In addition brief explanations of bactericidal tubes, black-light sources, strobotrons, photo-electric tubes, cathode-ray tubes, iconoscopes and image-dissector tubes, recorder tubes, x-ray tubes, and electron microscope.

This book would make a very valuable addition to a high school science library and a very helpful reference for any science teacher who wishes to keep up to date on how the electron works for us in the construction of electrical equipment which is all about him.

ESTIL B. VAN DORN
George Washington High School
Indianapolis, Indiana

APPLIED MECHANICS AND HEAT, by L. Raymond Smith, *Instructor in Industrial Physics, William L. Dickinson High School, Jersey City, New Jersey.* Cloth. Pages xii+326. 12.5×19 cm. 1943. McGraw-Hill Book Company, Inc., 330 W. 42nd Street, New York, N. Y. Price $2.00.

This book was prepared at the request of the War Department and the U. S. Office of Education in conformance with official pre-induction training course outline No. P.I.T. 102.

A text for Fundamentals of Machines course. The work covered is that of the usual physics course for the first semester. However, the method of presentation is different from the usual physics course because the author has included chapters that have been made possible through the cooperation of various forms and manufacturing plants so that the fundamental principles taught are made more important in the minds of students by their connection with up to date manufacturing plants and the consuming public in general.

Laboratory experiments are included and also suggested by clear-cut diagrams of apparatus used to varify principles of mechanics and heat. Physics teachers and shop teachers will appreciate the many interesting diagrams, illustrative problems, data outlines, tables of values, and interesting "hook ups" of apparatus which may be installed in the laboratory for continued use from year to year. Perhaps the three most unusual chapters are those on the Practical Study of Machines with its diagrams on efficiency of machines under different loads and lifting efforts; the Mechanical Transmission of Power with its treatment of the devices: shafts, couplings, clutches, cams, links, screw threads, chains and sprockets, friction devices and toothed gears; and the chapter on Fuels. The Appendix contains eight pages of very useful and interesting data.

ESTIL B. VAN DORN

AN ELEMENTARY COURSE IN QUALITATIVE ANALYSIS, by William Lloyd Evans, Jesse Erwin Day, and Alfred Benjamin Garrett, *The Ohio University.* Paper. Pages v+240. 19.5×26.5 cm. 1942. Ginn and Company, Statler Building, Boston, Mass. Price $2.25.

The organization and manner of treatment of the subject are essentially the same in this new edition as in the previous edition. The presentation is very direct and is well suited for the transition from general chemistry to

qualitative analysis. The manual would appear to be a very excellent one for teaching qualitative analysis at the high school or junior college level.

The main portion of the manual is devoted to a description of the laboratory procedure and the reaction involved. The cations are introduced by simple lecture demonstrations and following this the laboratory procedure is divided into separation and precipitation, confirmatory, and supplementary reactions. The anion analysis is treated similarly and is complete but not as systematic, perhaps, as could be desired. All of the procedures are devised for macro scale technique. A smaller section at the back of the book contains a brief and simple approach to such things as ionization, hydrolysis, and solubility product constants.

As an aid to the student the manual has block outline procedure sheets, flow sheets, and detachable answer sheets at the end of the discussion for each group. In addition there are detachable sheets on which the student may record the results of his laboratory work for each unknown. The tables included in the appendix are logarithms, solubilities, atomic weights, electromotive series, and summaries of the reactions of the cations and anions.

V. Boekelheide
Urbana, Illinois

Fundamentals of Machines, by John A. Clark, *Head of Department of Physical Science, Alexander Hamilton High School, Brooklyn, New York,* Frederick Russell Gorton, *Formerly Head of the Department of Physics, Michigan State Normal College,* Francis W. Sears, *Associate Professor of Physics, Massachusetts Institute of Technology,* and Major Francis C. Crotty, *U. S. Army, Director of Training, Watertown Arsenal, Watertown, Massachusetts.* 1st Edition. Pages xviii + 300. Photographs, 275 Figures. 1943. Cloth. List Price $1.24. 15×22 cm. Houghton, Mifflin Co., Boston, Mass.

Several books have been published at the request of the War Department and the U. S. Office of Education. *Fundamentals of Machines* is one of these in conformance with official pre-induction training course outline PIT No. 102. In a most direct way the authors have assembled subject matter covering topic by topic the aforementioned outline. Striking photographs given a modern touch to every unit under discussion. Problems are introduced in connection with the text material with adequate figure illustration. The exposition is easy to follow, being presented in a style most interesting and to the point. Utilizing the average known experiences of the student, the writers introduce additional principles in a progressive pedagogic sequence. Within its scope it is sufficiently complete. The content is gears to twentieth century teaching methods.

Lumin P. Brazda

Fundamentals of Machines, by Charles E. Dull, *Supervisor of Science for Junior and Senior High Schools, Newark, New Jersey,* and Ira G. Newlin, *Head of the Science Department, Scarsdale High School, New York.* 1st Edition. Pages xvi + 547. Numerous drawings, charts, and diagrams. 14×19½ cm. 1943. Cloth. List price $1.48. Henry Holt and Company, New York, N. Y.

As the title page states, this book has been prepared at the request of the War Department and the U. S. Office of Education n conformity with official pre-induction training course outline PIT-102. The authors have massed together material pertinent to this outline in the language adaptable to the junior or senior high school student. They have approached the subject with illustrations familiar to the student and then incorporated

the less familiar. The text is amply furnished within each training unit, while thought-provoking questions complete each chapter. It provides for the immediate want in a field for which it is intended.

A series of selected experiments with directions supplement the text material at the end of the book. Tables, Formulas, Chemical Equations, Mathematical Pointers, and a Glossary are to be found in the Appendix. All in all, *Fundamentals of Machines* is a text abounding in material that meets the need for accelerated training.

LUMIN P. BRAZDA

ALGEBRA (MATHEMATICS FOR TECHNICAL TRAINING), by Paul L. Evans, *Instructor in Mathematics, Engineering Division Curtiss-Wright Technical Institute, Glendale, California.* Cloth. Pages viii+126. 1×14×21 cm. 1942. Ginn and Co., Chicago. Price $1.25.

This book, *Algebra*, is the first in the series "Mathematics for Technical Training." The others in the series being *Plane Trigonometry with Tables* and *Calculus.*

Topics most applicable to the training of engineers are included and very little explanation. "Nonessential" topics are purposefully omitted. The material is arranged for a short course for technical students. It includes mainly a review of secondary school algebra. Such topics as the binomial theorem, progressions, series, permutations and combinations, and probability are omitted.

Chapters 9–12 are titled: Quadratic Equations, Properties and Graphs of Quadratic Equations, Simultaneous Quadratic Equations, and Theory of Equations. A supplementary chapter is titled: Ratio, Proportion, and Variation.

JOSEPH J. URBANCEK
DePaul University

GEOMETRY WITH MILITARY AND NAVAL APPLICATIONS, by Willis F. Kern, *Associate Professor of Mathematics at the United States Naval Academy*, and James R. Bland, *Associate Professor of Mathematics at the United States Naval Academy.* Cloth. viii+152. 1×14×21 cm. 1943. John Wiley and Sons, Inc., New York. Price $1.75.

The aim of the book is to present the fundamental, practical essentials of solid geometry. How the subject is used in solving problems arising in the army and navy is indicated in fully illustrated problems. The pictures are not only interesting but serve the purpose of enabling the student to visualize and see the applications. An aspect, space intuition, of solid geometry is developed by means of the concrete applications and examples.

Most of the problems and examples relate to familiar objects of everyday experience or to military and naval situations.

A brief treatment of trigonometry is given in the appendix. Four place tables of logarithms, of natural trigonometric functions, and of logarithms of trigonometric functions are included.

JOSEPH J. URBANCEK

PLANE TRIGONOMETRY WITH TABLES, by Paul L. Evans, *Instructor in Mathematics, Engineering Division, Curtiss-Wright Technical Institute, Glendale, California.* Cloth. Pages viii+108+84 pages of tables. 15×21.5 cm. 1942. Ginn & Co., Bowton, Mass.

This is the second in the series "Mathematics for Technical Training," which comprises *Algebra, Plane Trigonometry,* and *Calculus* in the complete series. Circular measure and the mil are taken up at the outset. The

first definitions of the trigonometric functions to be presented are those of the general angle in any quadrant. The book presents the usual topics of plane trigonometry. A good chapter on the slide rule is included, explaining the use of the A, B, C, D, CI, DF, CF, K, S, ST and T scales. A simple rule is given for locating the exact position of the decimal point in slide rule calculations. The tables used are taken by permission from other Ginn & Co. books, namely, Wentworth-Smith, J. Shibli, and Milne-Davis. The book is good for a concise presentation of trigonometry, but teachers in schools having long semesters would require supplementary material from other sources.

GLENN HEWITT
Von Steuben H. S., Chicago

ELEMENTARY APPLIED ELECTRICITY, by L. Raymond Smith, ***Instructor in Industrial Physics, William L. Dickinson High School, Jersey City, New Jersey, Member American Society of Mechanical Engineers.*** Third Edition. Cloth. Pages xiii+311. 12×19 cm. 1943. McGraw-Hill Book Company, Inc., 330 W. 42nd Street, New York, N. Y. Price $2.00.

The second edition of ***Elementary Electricity*** has been revised to meet pre-induction class needs. Three new chapters have been added: one on Static Electricity; one on Electric Lighting; and one on Current Rectification. The new chapter on lighting includes an excellent discussion of neon and fluorescent lighting. The subject is presented in excellent logical sequence with emphasis on fundamental principles and practical applications of the theories. Technical terms and language have been avoided whenever possible. Examples of methods of making the necessary calculations are provided. Students should be able to do the work without the aid of an instructor if the necessity arises. Main topics are listed at the close of the chapters and appear in italics in the discussions.

The scope of the material covered is best shown by a listing of chapter headings which follows: Fundamental Units and Ohm's Law; Series and Parallel Circuits; Electric Power-Heating Effects; Resistance of Wires; Methods of Measuring Resistance; Transmission of Current; Chemical Effects of Current; Primary Batteries; Storage Batteries; Magnets and Magnetism; Magnetic Effects of Current; Induced Electromotive Force; Direct Current Generators; Direct Current Motors; Dynamo Losses and Efficiency; Electrical Measurements; Alternating Currents; Static Electricity; Electric Lighting; Rectification of Current. The chapter on static electricity might have been woven into the discussion in the first chapter to better advantage.

ROGER J. WEAVER
George Washington H. S.
Indianapolis, Indiana

FUNDAMENTALS OF ELECTRICITY, BASED ON MATERIAL DEVELOPED FOR THE TEACHING OF LEARNERS AND APPRENTICES OF THE CARNEGIE-ILLINOIS STEEL CORPORATION. REWRITTEN TO CONFORM TO THE PREINDUCTION TRAINING COURSE IN FUNDAMENTALS OF ELECTRICITY AS PREPARED BY THE WAR DEPARTMENT. Cloth. Pages vii+194. 15.5×23.5 cm. 1943. American Book Company, 360 N. Michigan Avenue, Chicago, Ill.

This defense training textbook is suitable for a preinduction training textbook. The course was originally prepared as a means of training workmen in the industry. The book is so written that ninety periods are required to cover the subject. Nine of the ninety lessons are to be devoted to laboratory work. It is assumed that the student has had no previous knowledge

of the subject matter. It is adapted to the high school age student as well as to the adult learner. Mathematics has been avoided as much as is possible. Questions are provided at the close of each chapter. The cover of the book fails to do justice to the contents. The illustrations are refreshingly different. An idea of the contents and the logical development of subject matter may best be obtained by glancing at the headings of discussions which are as follows: Electron Theory; Types of Electricity; Sources of Current; Voltage; Current; Resistance; Circuits; Electromagnetism; Meters; Electromagnets; Heating Effects of Current; Work; Power; Energy; Induced E.M.F.; Motors; Mutual and Self-induction; and Current Rectification. This is truly a splendid text for those seeking a source of electrical theory, information.

ROGER J. WEAVER

FUNDAMENTAL JOBS IN ELECTRICITY, by Edgar C. Perry, A. M., *Superintendent of Schools and Director of Defense Training Classes, Indiana, Pennsylvania;* Harry V. Schafebook, *Instructor in Electricity, John B. Stetson Junior High School, Philadelphia, Pennsylvania.* Cloth. Pages xiv+447. 14.5×23 cm. 1943. McGraw-Hill Book Company, Inc., 330 W. 42nd Street, New York, N. Y. Price $2.20.

Fundamental Jobs in Electricity is a splendid non-vocational textbook consisting of a series of jobs which should have appeal for boys. The jobs selected are modern, practical jobs covering all of the aspects of electrical theory usually covered in elementary courses of electricity. Detailed instructions are provided for the student, thereby reducing the work of the instructor. The material has been tested in the authors' classes for two years, revised and again tested for a period of three years before publication. The course is planned to provide enough material to cover two years of instruction. Review questions and references are provided at the close of each discussion. There are numerous clear illustrations closely related to the subject matter.

It is possible that more emphasis has been given to signal wiring than is necessary and that *Ohm's Law* and *Resistance* have been somewhat slighted. The use of meters has been largely omitted, perhaps because beginning students are apt to damage such delicate equipment. The section concerning light and power wiring is especially good. Discussions of fluorescent lighting; the operation and use of alternating current motors under varying conditions; and electric fence controllers, are all very practical. The authors are to be commended for including them. This textbook should be most helpful to teachers in both city and consolidated schools. It should help to popularize the subject and lead to the formation of new classes in the subject. It is the type of book that teachers have been seeking.

ROGER J. WEAVER

POSTWAR JOBS IN VOCATIONAL REHABILITATION

Returning soldiers, ex-war workers, students, teachers, parents, counselors, and others who want to know about professional opportunities in helping injured persons to re-establish themselves economically, will want to read the composite summary of available literature on *Vocational Rehabilitation as a Career* just completed by Sarah Allen Beard and published by Occupational Index, Inc., New York University, New York 3, N. Y. Single copies are 25¢ cash with order.

This is the fourth in a new series of Occupational Abstracts, covering occupations in which postwar employment prospects are good. The editor of the series is Professor Robert Hoppock of New York University. Advance orders for the next 10 in the series may be placed now at $2.50.